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A Summary of Current Program and
Preliminary Report of Progress

OILSEED AND PEANUT CROPS RESEARCH

of the

United States Department of Agriculture

and related work of the

State Agricultural Experiment Stations

This progress report is primarily a research tool for use of scientists and administrators in program coordination, development, and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of research progress include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members, and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the past year. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C. 20250

December 1, 1967

RESEARCH ADVISORY COMMITTEES

The following Research Advisory Committees were established pursuant to Title III of the Research and Marketing Act of 1946:

1. Farm Resources & Facilities
2. Utilization
3. Human Nutrition & Consumer Use
4. Marketing
5. Agricultural Economics
6. Forestry
7. Animal & Animal Products
8. Cotton
9. Grain and Forage Crops
10. Horticultural Crops
11. Oilseed and Peanut Crops
12. Plant Science & Entomology
13. Sugar
14. Tobacco

The source materials used by the advisory committees include organizational unit progress reports and subject matter progress reports. The latter contain information which was first reported in the organizational reports and has been assembled for use by commodity committees. The number prefixes shown below refer to advisory committees listed above.

ORGANIZATIONAL UNIT PROGRESS REPORTS

Agricultural Research Service (ARS)

1 - Agricultural Engineering
1 - Soil & Water Conservation
2 - Utilization -- Eastern
2 - Utilization -- Northern
2 - Utilization -- Southern
2 - Utilization -- Western
3 - Human Nutrition
3 - Consumer & Food Economics
4 - Market Quality
4 - Transportation & Facilities
7 - Animal Husbandry
7 - Animal Disease & Parasite
12 - Crops
12 - Entomology

Economic Research Service (ERS)

1, 5 - Economic Development
4, 5 - Marketing Economics
5 - Farm Production Economics
5 - Economic & Statistical Analysis
5 - Foreign Development & Trade
5 - Foreign Regional Analysis
5 - Natural Resource Economics

6 - Forest Service - Research (FS)

4, 5 - Farmer Cooperative Service (FCS)

4, 5 - Statistical Reporting Service (SRS)

SUBJECT MATTER PROGRESS REPORTS

6 - Forestry (other than Forest Service)
7 - Animal-Poultry and Products Research Other Than Husbandry, Disease and Parasite
8 - Cotton and Cottonseed
9 - Grain and Forage Crops
10 - Horticultural Crops
11 - Oilseed and Peanut Crops
13 - Sugar
14 - Tobacco

A copy of any of the reports may be requested from Max Hinds, Executive Secretary, Oilseed and Peanut Crops Research Advisory Committee, Research Program Development and Evaluation Staff, U. S. Department of Agriculture, Washington, D. C. 20250

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INTRODUCTION

This report deals with research directly related to the production, processing, distribution, and consumption of oilseeds and peanuts, and oilseed and peanut products. It does not include extensive cross commodity work, much of which is basic in character, which contributes to the solution of not only oilseed and peanut problems but also to the problems of other commodities. Progress on cross commodity work is found in the organization unit reports of the several divisions.

The report is presented under three main headings: Farm Research; Nutrition, Consumer and Industrial Use Research; and Marketing and Economic Research. There is also a breakdown by problem areas as shown in the table of contents. For each subject matter area, there is a statement of the problem, USDA and cooperative program, information about the program at the State Experiment Station, if available, a summary of progress during the past year on USDA and cooperative programs and a list of publications.

Oilseed and peanut research is supported by (1) Federal funds appropriated to the research agencies of the U. S. Department of Agriculture, (2) Federal and State funds appropriated to the State Agricultural Experiment Stations, and (3) private funds allotted, largely by oilseed and peanut industries, to research carried on in private laboratories or to support of State Station or USDA work.

Research by USDA

Farm Research in the Agricultural Research Service dealing with oilseeds and peanuts comprises investigations on breeding and genetics, variety evaluation, culture, diseases, nematodes, weed control, insects, and crop harvesting and handling operations and equipment. This research is conducted by the Crops, Entomology, and Agricultural Engineering Research Divisions. The work involves 86 scientist man-years of scientific effort.

Nutrition, Consumer and Industrial Use Research in the Agricultural Research Service pertains to improved methods and equipment for mill processing of oilseeds and peanuts; development of new and improved food, feed, industrial uses of oilseed and peanut products; and nutrient values of oilseeds and peanuts. It is carried out by the Northern, Southern, and Western Utilization Research and Development Divisions; Consumer and Food Economics Research Division; and Human Nutrition Research Division. The work in these divisions involves 104 scientist man-years of scientific effort.

Marketing and Economic Research is done in three services. Marketing research in the Agricultural Research Service dealing with oilseeds and peanuts is concerned primarily with the physical and biological aspects of assembly, packaging, transporting, storing and distribution from the time the product leaves the farm until it reaches the ultimate consumer. It is

conducted by the Market Quality Research Division and the Transportation and Facilities Research Division. The oilseed and peanut research in these divisions involves 12 scientist man-years of scientific effort.

Economic research conducted in the Economic Research Service deals with marketing costs, margins, and efficiency; market potentials; market structure, practices, and competition; outlook and situation; and supply, demand and price. Research in cooperative marketing is conducted by the Farmers Cooperative Service. The oilseed and peanut research in these services involves 8 scientist man-years of scientific effort.

Interrelationships among Department, State, and Private Research

A large part of the Department's research is cooperative with State Experiment Stations. Many Department employees are located at State Stations and use laboratory and office space close to or furnished by the station. Cooperative work is jointly planned, frequently with the representatives of the producers or industry affected participating. The nature of cooperation varies with each study. It is developed so as to fully utilize the personnel and other resources of the cooperators which frequently includes resources contributed by the interested producers or industry.

Including both cooperative and State Station projects, oilseed and peanut research is in progress in about half of the 53 State Agricultural Experiment Stations. The type of work to which the largest amount of effort is devoted includes breeding and genetics, culture, diseases, variety evaluation, insect control, weed control, agricultural engineering, utilization, and economics. There is regular exchange of information between Station and Department scientists to assure that the programs complement each other and to eliminate unnecessary duplication.

Industry's participation in oilseed and peanut research is carried out primarily by manufacturers of farm machinery and equipment, processors of intermediate products such as refined vegetable oil, and by manufacturers of consumer products such as shortening, margarine, and peanut butter.

Basic research done by the Department and States is utilized by industrial research laboratories in further development of improved products and equipment. Industry's cooperation in supporting oilseed and peanut research at Federal and State Stations has contributed greatly to its success.

Examples of Recent Research Accomplishments by USDA and Cooperating Scientists

Soybean Nematode Survey. A survey of 28 major soybean-producing counties in Alabama, Florida, and Georgia, showed that 11 important genera of plant-parasitic nematodes were associated with crop damage. Soil populations in soybean fields often exceeded 2,000 parasitic nematodes per pint of soil. Plants were frequently stunted, chlorotic, and had damaged root systems. Root-knot and sting nematodes were most common in sandy soils, while spiral, root-lesion, and pin nematodes were most common in heavier soils. In severely infested fields, crop losses approached 40 percent.

Cyst Nematode Resistant Soybean Varieties. Custer and Dyer, two new cyst nematode resistant varieties, were released to certified growers. These two varieties, together with Pickett, will provide resistant varieties for all areas where the cyst nematode has been found. Resistance to the cyst nematode will reduce the hazard of growing soybeans in infested fields and make continued production possible.

Crop Preparation and Farm Processing. Peanuts must undergo a curing process to develop and maintain proper quality for consumer acceptance. Research at the Oklahoma Agricultural Experiment Station indicated that curing using dielectric or internal heating with reduced air flows can result in better and faster curing. Research is being continued to further develop this curing method.

New catalyst for producing improved edible soybean oil products. A copper-containing hydrogenation catalyst has been developed by Department scientists for use in production of edible soybean oils having improved flavor stability. They also discovered that after a special activation process a commercial copper catalyst was highly effective in treatment of soybean oil with hydrogen for selective removal of linolenate, the unstable component of the oil. Salad oils containing less than 1 percent of linolenate will be easily produced with the aid of the new catalyst. At the same time, most of the nutritionally desirable linoleate will be retained. Since no solid fats are formed, the added cost of winterizing to remove hardened products will be eliminated. "Olive oil" type cooking oils will result from more drastic hydrogenation treatment. The new catalysts are being tested by commercial salad oil producers. The treated oils are expected to have the stability needed to withstand storage and transportation for foreign marketing. Possibilities are, therefore, substantially enhanced for soybeans to play a major role in overcoming the annual world food deficit of 4 billion pounds of food fats and oils.

Village Process for edible soy flour demonstrated in Brazil. Department engineers have developed a "village process" for use in developing countries for making high-grade, full-fat soy flour for food use. The equipment is hand operated and may be purchased for $280. By this process, 300 pounds of flour can be produced in an 8-hour day. These 300 pounds supply half of the daily requirement of protein for 1,600 adults.

After a visit to the Department by the Director General of the National Children's Bureau, the Brazilian Ministry of Health acquired equipment for the "village process" through UNICEF and asked the Department to demonstrate the process and to provide technical assistance. Two sets of processing equipment have been delivered and four additional sets are on order for different areas of Brazil. A Department engineer went to Brazil to give instructions on operation of the equipment to staff members and groups of doctors, nutritionists, and social workers of the National Children's Bureau, Ministry of Health, of Brazil. These groups in turn will train task groups to operate the process in the interior parts of Brazil for the purpose of improving nutrition among young children suffering from dietary protein deficiency.

Identity-preserved soybeans marketed for Oriental foods. United States-produced soybeans are finding increased markets in Oriental foods, resulting from a research study by Department scientists in cooperation with Japanese workers. Solutions have been found to the previous objections to U. S. soybeans such as uneven cooking, dark-colored products, and undesirable flavors. Processing techniques, evaluation procedures, and the selection of U. S. soybean varieties that give products with specific tastes and flavors desired by foreign users have resulted in shipment of increasing quantities of identity-preserved soybeans to Oriental countries. These U. S. soybeans are now preferred to those grown by the countries themselves, or imported from countries such as Mainland China.

At least three companies are now exporting several million bushels annually of identity-preserved beans. This is a growing cash market. For example, in Japan where 40 percent of the soybean consumption is used to produce traditional soybean protein foods, U. S. imports have increased from 40 million bushels in 1962 to 65 million in 1966.

High Quality Cottonseed and Peanut Flours Produced Experimentally for Human Consumption in Developing Countries. Progress has been made in cooperative research with the Agency for International Development (AID) and other organizations that are assisting developing countries to use cottonseed and peanuts in meeting their food needs. A quantity of cottonseed flour prepared at the Southern Division received long-term clinical testing in Peru as the sole source of protein given children suffering from protein deficiency and malnutrition. The physician in charge reported that this flour gave results virtually indistinguishable from those produced by skim milk products. More recently, cookies prepared by the Human Nutrition Research Division from low-fat peanut flour produced at the Southern Division were well liked by a group of 45 African women from ten different countries. Peanut flour also gave good to excellent results in such diverse preparations as beverages for babies, breads, chapatis, curry, garbanzo stew, pancakes, and noodles. Other batches of materials prepared from these oilseeds are being evaluated by various governmental, academic, or commercial agencies in the United States and in several foreign countries, including

England, Canada, and Egypt. Solvent extraction systems now being investigated appear to offer promise of yielding products with acceptably bland flavor. Practical processes will be developed to enable relatively small installations in developing countries to produce high-quality flours from both cottonseed and peanuts.

Discovery of Color Precursor Leads to New Recovery Processes for Safflower Seed Oil. Several years ago breeding work on safflower produced new, thin-hull varieties that yield up to 25% more oil than the commercially used Gila seeds. Oil extracted from the thin-hull varieties, however, was not acceptable because of its dark color which could not be removed sufficiently by standard refining procedures. Research by Department scientists has now shown that the dark color is formed from a colorless precursor which is extracted with the oil from the kernel portion of the seed. It condenses to a dark pigment during processing when temperatures are above 100° C. The color precursor, but not the pigment itself, can be removed from the oil by extraction with water or alkali.

These findings have led to three different laboratory processes for thin-hull safflower seeds, yielding oil that is free of dark color and precursor. No serious difficulties are anticipated in developing a commercial-scale process that will make thin-hull varieties usable and bring advantages to the grower, processor, and consumer. In addition, a microtest developed for detecting the color precursor in safflower seeds may help plant breeders produce new high-oil safflower varieties free of color precursor.

Superior Foam Plastics from Castor Oil. Semi-commercial scale preparation and evaluation of castor oil-based rigid urethane foams has been completed by cooperation with industry, using formulations based on those developed by Department scientists. These foams have great potential for use in structural panels and as a superior insulating material. Low-cost castor oil-based foams appear particularly well suited for spray-on applications where adhesion and foam quality are excellent and in the increasingly popular "froth" applications where use of a lower boiling blowing agent reduces problems due to exothermic heat build up and shrinkage. These findings should win for castor oil a larger share of the 200 million pounds per year market (1970 estimates) for rigid urethane foams.

Method for rapid, accurate analysis of moisture and oil content developed

A method for rapid, accurate analysis of moisture and oil content in a wide range of commodities has been developed. Near infrared-absorption technique can be used on any sample which can be prepared into a homogenous thin layer of uniform thickness. Proper choice of wavelength for analysis permits measurement of moisture content on dehydrated materials as well as on tissue from fresh fruits and vegetables. This development should have particular application in laboratory evaluation of composition of agricultural commodities and it should be possible to develop an instrument suitable for grading applications.

This near-infrared-absorption technique has a potential for reducing the time to 5 minutes or less required for making official oil and moisture content determinations. Presently, the official method for soybeans requires an elapsed time of 12 hours, using a hazardous ether extraction process. For meats, three hours elapsed time is required including 30 minutes time of a professional chemist. Less skilled operators could make this direct measurement on a laboratory type instrument.

Soybeans.--A recent study shows that Louisiana soybean producers can increase their net income by $1 million in 1967 and by as much as $4 million in 1970 by adopting improved methods of cooperative storage, handling, and transportation.

I. FARM RESEARCH

SOYBEAN BREEDING AND GENETICS, DISEASES, CULTURE, QUALITY, AND PHYSIOLOGY

Crops Research Division, ARS

Problem. Average yield per acre must increase if soybeans are to hold present acreage and continue to expand. Soybean research is directed toward producing higher average yield since available land for further acreage increases is limited. Because the adaptability of soybean varieties is critically affected by the relative length of days and nights and other biological and environmental factors, it is necessary to develop varieties adapted to specific conditions.

Soybeans are important commercially because of their high content of oil and protein. Historically, the levels of these two important constituents have been negatively correlated, and protein negatively correlated with seed yield. It is difficult, therefore, to combine breeding programs seeking to improve yield, oil, and protein. This dilution of research effort to cover several objectives reduces progress toward any one objective. In addition, research is needed to characterize genetic variation in the components of oil (fatty acids) and protein (amino acids). If, by breeding and agronomic practices, linolenic and linoleic acid in the oil could be reduced, soybean oil would be in a more favorable position on the world market. Also, if the amino acid methionine could be increased, the protein from the soybean would have a greater nutritional value. Some progress has been made in this area but more research is needed.

Much of the increased yield in nonlegumes in recent years can be attributed to nitrogen fertilization. The soybean, as a legume, has an endogenous source of nitrogen in the symbiotic nodule system. There are many strains of the nodulating bacteria in the collection. These strains differ in compatability with different soybean genotypes, in adaptability to soil conditions, and probably in the effectiveness with which they are able to fix atmospheric nitrogen in the symbiotic relationship. More detailed and precise information about bacteria-nitrogen-soybean interactions is a pressing need in the research program, and is receiving attention from several aspects.

Soybean diseases in recent years have increased to the level that certain diseases may approach catastrophic levels for some farmers. Genetic resistance has proved an effective method of dealing with certain diseases. However, the search for resistance requires screening many thousands of genotypes in the seed collection and is time-consuming. Once resistance has been found, incorporation into good agronomic types may be simple or complex, depending on the number of genetic factors, linkages, and the ease with which resistance can be identified. Adequate resistance has not been found for some of the most important diseases.

Efficient use of light-energy and nutrients is necessary if maximum production per acre is to be obtained. Research needs to be intensified in understanding the photosynthetic process. Variability in the use of nutrients from the soil has been observed. An understanding of the mechanism involved in nutrient uptake and use, and the interrelation among the nutrients is needed. Increased yield in many crop species has been obtained by hybridization. Cross-pollination by hand in soybeans is very tedious and no male sterility system has been discovered. Techniques to increase natural crossing and new efficient methods for handling segregating material are needed. Some research is being conducted in this area.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving breeders, geneticists, pathologists, physiologists, and chemists engaged in both basic studies and the application of known principles to the solution of growers' problems. Research is conducted at Beltsville, Maryland, and in cooperation with Agricultural Experiment Stations of California, Florida, Illinois, Indiana, Iowa, Maryland, Mississippi, Missouri, and North Carolina. In addition, the evaluation of experimental selections is conducted in formal cooperation with the Experiment Stations of Alabama, Arkansas, Georgia, Kansas, Kentucky, Louisiana, Michigan, Minnesota, Nebraska, North Dakota, Ohio, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Virginia, and other soybean producing States.

Cooperative agreements, contracts, and grants are in effect for research in mycotoxins (Iowa and Illinois Agricultural Experiment Stations), root growth (Indiana and Illinois Agricultural Experiment Stations and Virginia State College), biochemical nature of nematode resistance (Boyce Thompson Institute for Plant Research), resistance to soybean cyst nematode (Missouri Agricultural Experiment Station), photosynthesis (North Carolina and Iowa Agricultural Experiment Stations), nucleic acids (Indiana Agricultural Experiment Station), rapid methods of determining amino acids (Arthur D. Little, Inc.), responses of soybean tissue culture challenged by pathogenic and symbiotic bacteria (Minnesota Agricultural Experiment Station), development of soybean germplasm adapted to California, (University of California Experiment Station), seed deterioration and hypocotyl elongation (Iowa Agricultural Experiment Station), epidemiology of Cephalosporium gregatum (Iowa State University), and histology and cytopathology of soybean pods and seed invaded by Diaporthe phaseolorum var. sojae and Cercospora kikuchii (Delaware Agricultural Experiment Station), and a comprehensive literature review of soybean morphology (Minnesota Agricultural Experiment Station).

One PL 480 project entitled, "Differential competition among strains of Rhizobium japonicum for nodule sites on soybeans" is in effect with the Burdwan University, India.

The Federal intramural scientific effort devoted to soybean production, breeding, disease, and quality research totals 29.3 scientist may-years. Of this number, 8.0 is devoted to breeding and genetics; 8.3 to diseases; 3.9 to culture; 4.1 to quality; and 5.0 to physiology.

Scientist man-years represented in extramural research agreements totals 5.4. Of this number, 0.3 is devoted to breeding and genetics; 1.9 to diseases; 1.2 to culture; 0.7 to quality; and 1.3 to physiology.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 45.3 scientist man-years is devoted to this area of research.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Breeding and Genetics

1. Breeding

a. New Varieties. 'Hark' developed in Iowa and adapted to northern Iowa and similar latitudes in other states, was released in cooperation with six Midwestern Agricultural Experiment Stations. This variety is superior in yield to other varieties grown in the adapted area. It is not recommended where phytophthora root rot is a problem.

Three large-seeded soybean varieties, 'Disoy', 'Magna', and 'Prize' were developed at Iowa and released in cooperation with four Agricultural Experiment Stations. These varieties cover an area from 40 - 45° latitude. Their performance is superior to that of large-seeded varieties presently being grown, and comparable to smaller seeded varieties used in the crushing industry.

'Verde', a large-seeded variety with green cotyledons and seedcoat was released in cooperation with the Delaware Agricultural Experiment Station. Verde is adapted to Delaware and will be utilized as a canned or frozen product.

'Kino' developed in Arizona and released in cooperation with the Mississippi and Arizona Experiment Stations, is particularly adapted to Arizona. Under these conditions it exceeds the currently grown variety Lee.

b. Cyst nematode resistant varieties. 'Custer' and 'Dyer', two new cyst nematode resistant varieties, were released to certified growers in cooperation with four Agricultural Experiment Stations. These two varieties and the later variety Pickett will provide resistant types for all areas where the cyst nematode has been reported. Custer, developed in Missouri, is also resistant to phytophthora root rot. Dyer, developed in Mississippi and Tennessee, is resistant to the root knot nematode but is not resistant to phytophthora root rot.

c. Breeding for disease resistance. Present efforts are to incorporate into advanced material resistance to several pathogens. Incorporation of cyst nematode, root knot nematode, and phytophthora root rot resistance has been accomplished and, is in advanced line test. Cyst nematode resistance is being incorporated into early lines. Incorporation of phytophthora, bacterial pustule, and frogeye race 2 resistance into a desirable agronomic type is being attempted. Evaluations are continuing in search of a high level of resistance to the brown stem rot organism, Cephalosporium gregatum. Crosses have been made and early generation progeny is being evaluated using a plant introduction with a low level of resistance to the brown stem rot.

Genotypes resistant to organisms causing poor seed quality have been selected. Crosses have been made with good agronomic types and early generation progeny is being evaluated. No consistent relationship has been found between maturity and seed quality.

Lines were selected for differences in reaction to three diseases; bacterial blight, bacterial pustule, and target spot. Based on results from 5 tests over a 3 year period, bacterial pustule reduced yield 12 percent, bacterial blight 10 percent, and target spot 9 percent.

Lines resistant and susceptible to phytophthora rot were evaluated on a sandy loam where phytophthora is not a problem. The susceptible lines yielded 10% more than the resistant lines. These results suggest a deleterious effect of the major gene for resistance or a closely associated gene.

d. Improved protein. Crosses involving high protein genotypes have been made. Preliminary tests indicate that high protein (46-47%) content, acceptable oil content (19%), and good yield can be achieved. A strain in the advanced stage of development is equal in yield to currently grown varieties and contains 43.2 percent protein and 20.5 percent oil.

Evaluation for methionine in the protein has continued. About 500 genotypes, mostly plant introductions, in maturity groups I, II, V, VI, VII, and VIII were analyzed. Methionine for this material ranged from 1.0 to 1.3 percent.

e. Improved oil. NMR (Nuclear magnetic resonance spectrophotometry) technique was established as an accurate, non-destructive method of analyzing for oil in oilseeds. This technique will be used in all routine analyses of soybeans for oil content in the future. Studies were complete on proper handling techniques for seeds to be analyzed by NMR to maintain viability. Drying the seed for 90 hours at 135° F was established as satisfactory for reducing the moisture to 3.4 to 3.6 percent without destroying viability. Studies are underway to determine if Xenia (direct effect of pollen on a seed character) exists for oil or the fatty acids. This is accomplished by oil and GLC analysis on a small portion of the cotyledons and using the remaining portion for the next generation.

f. Methods of breeding. Several methods of estimating oil and protein percentages in segregating populations were evaluated. The methods were seed density, NMR, Kjeldahl and solvent extraction. The Kjeldahl method gave the most reliable estimate of protein. NMR was found to be a rapid, accurate, and inexpensive estimator of oil percentage. NMR was superior to seed density as a non-destructive method to be used in mass selection for protein and oil. In a closely related study specific gravity was used for 2 cycles to stratify the population into high and low protein and oil components. Greater effectiveness was observed in cycle 1 where the genetic variability was greater for oil and protein than in cycle 2. These results agree with a previous experiment using specific gravity in mass selection for protein only.

It was determined from a study designed to characterize between- and within-plant variability for oil content in soybeans that two pods (2 seeds/pod) at the intermediate flowering node in the field and either the intermediate or basal node in the greenhouse were sufficient to classify plants as high and low oil plants with about 90 percent accuracy.

A comparison of a 9-hill-plot design with normal rod row-plot procedures suggests that the hill-plot arrangement should be effective in evaluating large populations for superior yield genotypes.

The effect of intergenotypic competition on yield and other attributes was evaluated in both hill and row plots utilizing four adapted varieties of different maturities. Certain genotypic combinations yielded more than the average of the two genotypes. This is called "overcompensation." Genotypic behavior in a competitive situation may be a reliable criterion for predicting superior varietal blends.

A theoretical model was developed to investigate the properties of competitive systems that might develop in bulk populations of autogamous homozygous lines as a result of overcompensation. The results indicate that competitive feedback may be a powerful force in the eventual establishment of stable equilibria in evolving populations. These populations would have greater reproductive capabilities than the mean of the component genotypes in pure stand.

2. Genetics. A true breeding BC_5 line combining two maturity genes with determinate stem (dt_1) was produced and grown. Inheritance of dwarfness in Adams and Lincoln indicate that the dwarf types are Df_2 Df2 df_3 df3 and df_2 df_2 Df_3 Df_3 respectively.

Seed proteins of 61 varieties were analyzed by disc electrophoresis. The stained protein in polyacrylamide gel revealed two components that separated the varieties into two groups. Crosses were made between selected varieties from each group. Data from the segregating generations of these crosses indicated the difference between the groups to be controlled by a

single gene. The heterozygous type was intermediate and no new bands were observed.

Heterosis effects (F_1 over high parent) were measured with the following values: dry weight 23.4%, and seed yield 22.9%, height 9.2% and maturity 1.5% over late parent. Seed size decreased 15.2% from the high parent. These are larger values than had previously been reported for heterosis in soybeans.

B. Diseases

1. Disease distribution. As in previous years diseases were present in all fields surveyed. Of the foliage diseases, bacterial blight, bacterial pustule, downy mildew and brown spot were the most prevalent. Brown stem rot was found in 55% of 487 Iowa fields. The disease was found in 91% of the 97 counties sampled. One field in which soybeans had not been grown in three years had 90 to 100% of the plants infected. Further research based on the results from this field have confirmed red clover as an alternate host. Bud blight continues to be a problem in many soybean producing areas.

2. Races and complexes of disease organisms. Xanthomonas alfalfae was tentatively identified as pathogenic to soybeans. It produces a leaf blight similar to that caused by Pseudomonas glycinea but has a different varietal reaction. Research to determine the cause of reduced stands and post-emergence damping-off of the variety Hood indicates two species of Pythium are the pathogens. One of these has been identified as P. ultimum. The variety Semmes possesses a moderate degree of resistance to both species. A seedling disease was observed with symptoms similar to that caused by P. ultimum. The causal organism was found to be Penicillium sp.

Cross-protection of susceptible Harosoy against Phytophthora megasperma var. sojae was accomplished using the non-pathogens Helminthosporium sativum, H. turcicum, Ceratocystis fimbriata, and Gibberella zeae. It appears these organisms can stimulate the production of phytoalexin in soybean as a defense against P. megasperma var. sojae.

A microplot experiment demonstrated no predisposition of Lee soybeans to brown stem rot by 6 species of nematodes.

3. Virus investigations. Serological studies have confirmed that all plants of the variety Hood are infected with the soybean mosaic virus. Manometric O_2 uptake measurements by 1 cm apical growing points from Hill and Lee at various times after sequential inoculations with soybean mosaic virus and bean pod mottle virus indicated that respiration rates are generally lowered by virus infection. Greenhouse and field studies of seed mottling caused by SMV confirmed the previous 5 years' field data and showed that seed mottling of Hill and Lee is negligible when SMV is absent. Studies are underway to study transmission of tobacco ringspot virus by thrips.

4. Phytophthora rot studies. P. capsici and P. parasitica were found pathogenic to soybeans. Therefore, P. megasperma var. sojae is not the only Phytophthora pathogenic to soybeans. Research on the genetic variability of P. megasperma var. sojae has continued. Ninety-seven isolates from susceptible soybeans indicated a predominance of race 1. Only one isolate was classified as race 2. Several isolates were more virulent than race 1 but less than race 2, indicating variation not represented by the two races. Using the above races, a soybean strain resistant to race 1 and susceptible to race 2 was inoculated with race 1 followed by inoculation 1-3 days later with race 2. Results showed that 40% of the plants were protected against race 2. This lends support to the phytoalexin theory in the nature of disease resistance.

Time-temperature relations of soybean resistance to P. megasperma var. sojae were conducted. Less than 15 minutes at 44° C is required to break the resistance of a soybean plant to P. megasperma var. sojae. A period of 18 to 20 hours is needed for the plants to recover the initial level of resistance.

5. Search for disease resistance. Hundreds of genotypes of introductions and lines from segregating populations were screened in search for agronomically desirable types resistant to frogeye leaf spot, downy mildew, tobacco ringspot, and Pythium ultimum. At present no good resistance has been found to brown stem rot. Where resistance or tolerance is available efforts are being made to incorporate these into resistant varieties. Screening of material is continuing in an attempt to identify material with good seed quality resulting from a complex of diseases.

6. Microorganisms associated with seed. Isolation of fungi from developing soybean seed was continued in 1965 and 1966. No isolations of Aspergillus flavus or any species of Penicillium have been obtained. The most common fungi isolated were Diaporthe phaseolorum var. sojae, Alternaria tenuis, Cercospora sojina, and Nigrospora oryzae.

C. Culture

1. Row spacing and plant community studies. Research emphasis is being placed on the evaluation of various plant attributes as they relate to the "canopy" or "silhouette" produced by a plant community. Differences in the depth which sunlight penetrates below the top of the plant have been observed. The deeper penetration was attributed to a smaller terminal leaf angle, smaller petiole angle, smaller petiole length, and less total leaf area and leaf weight. The hypothesis is that this deeper penetration of light below the tops of the plants leads to more photosynthesis and ultimately more yield. Also, from these studies, stages of growth 7 and 8 were considered the best stages to obtain dimensional and radiation data.

2. Nodulation studies. A62-3 and Amsoy each showed preferences for particular strains in a three-year study using 12 Rhizobium japonicum strains. Amsoy accepted the greater number of strains. An inoculation trial was conducted in soil with a very low number of R. japonicum present. Depth of planting and amount of inoculum applied both affected the number of nodules.

Significantly different serological patterns were observed on 15 varieties exposed to the same soil population of R. japonicum. This is further indication of variety preferences, or soybean-bacteria interactions. Differential competition and host specificity studies are continuing in the U.S. and in India.

D. Quality

Approximately 13,000 samples were analyzed for total protein and oil during the period of this report. The distribution of fatty acids in the oil of individual cotyledons and seed coats was studied. The results indicated that the oil content and fatty acid components for all parts of the cotyledon are similar. The root-shoot axis oil contained a greater proportion of linolenic and linoleic acid than the cotyledons. Soybean seed coats contain very little oil. The percentages of linolenic and linoleic acids are quite different in the black and yellow seed coats. Most of the oil is in the cotyledons, so changes in the axis or seed coat have only a small effect on results of analysis of the entire seed.

Amino acid analysis procedures were compared using gas-liquid chromatography and ion-exchange chromatography. Satisfactory results were obtained in most samples by GLC for six amino acids and by ion-exchange for 14. Results obtained by both methods were low for valine, isoleucine, and cystine.

E. Physiology

1. Nutrient relationships. Studies were conducted on yield response to N applications on soils low in organic matter and on the periods of active symbiotic nitrogen fixation. Significant yield increases were obtained by either broadcast or sidedressed nitrogen. No response was obtained from P and K applications and there were no N-level X P and K interactions. Good nodulation was observed where no N was applied. These results indicate either that inefficient strains of bacteria are in these soils or that the soybean is dependent upon some inorganic nitrogen from the soil. Earlier results from Iowa on high organic soil indicated that soybeans obtain about one-half their nitrogen from the soil when yielding in the 35-40 bushel range.

Using nodulating and non-nodulating isogenic pairs of lines in outdoor gravel culture, each strain absorbed practically the same quantities of NO_3, P, K, Ca and Mg throughout the growth period. However, there was a consistent increase in seed yield (15%) produced by the nodulating strain.

2. Metabolic studies. Metabolic activity of isolated soybean chloroplasts indicated that the light reaction in soybean photosynthesis is essentially identical to that in other green plants and in algae.

Photo-respiration is the phenomenon in which leaves, upon illumination, increase oxygen consumption and carbon dioxide evolution. The prime source of CO_2 evolved is thought to be carbon recently fixed in photosynthesis, specifically glycolic acid. Photo-respiration studies in soybean leaves indicated consistent differences between varieties in the activity of glycolic acid oxidase (GAO). Photosynthetic efficiency might be increased if GAO activity were reduced. This hypothesis is currently being tested.

Research is underway to characterize pyridine nucleotide metabolism, particularly the light controlled interconversion of NAD (DPN) and NADP (TPN) in the chloroplast. In light, the chloroplast converts some of its NAD, the respiratory cofactor, to NADP, the photosynthetic cofactor. However, approximately half of the NAD is not phosphorylated in the light and hence is useless to the plant during photosynthesis. The objective is to isolate and characterize the enzymes responsible for the interconversion of NAD to NADP and attempt by chemical or genetic means to manipulate it so that all chloroplast pyridine will be converted to NADP during illumination.

Studies have been directed toward isolation and purification of the enzymes involved in the synthesis of fatty acids from immature soybean cotyledons. Localization studies of the fatty acid synthesizing system from immature soybean cotyledons have shown that the enzymes involved in the conversion of acetate-1-C^{14} into the lipid soluble material are located in the supernatant fraction (soluble) after a 110,000 x G. centrifugation. Over 90 percent of the original fatty acid synthesizing activity found in the crude preparation can be accounted for in the soluble fraction if all enzyme isolation procedures are carried out at room temperature.

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OILSEED BREEDING, GENETICS, DISEASES, VARIETY EVALUATION, CULTURE AND PHYSIOLOGY, AND QUALITY

Crops Research Division, ARS

Problem. Eight oilseed crops with a wide range of uses and production problems are covered in this area. Crops included are safflower, peanuts, flax, castorbean, sesame, sunflower, crambe, and tung.

The major problem in safflower production is the transfer of seedling rust resistance to inbred varieties or breeding lines used in the production of F_1 seed for commercial planting. Heavy loss of stand from seedling rust has been experienced in 1967 in California, and could be a problem in other areas. Verticillium wilt is increasing in severity, particularly in Arizona and resistance is urgently needed. Hybrid safflower is needed to exploit hybrid vigor, increase yields, and reduce production costs.

The principal problems in peanuts are lowering the cost of production and improving quality. More information is needed on (1) control of destructive diseases, especially those caused by soil-borne microorganisms, including toxin-producing molds, and those caused by viruses; (2) the physiology of the plant, mineral nutrition, and environmental factors affecting growth, flowering, and fruiting; (3) breeding behavior of the crop; and (4) identifying and measuring characteristics of peanuts associated with quality for specific consumer demands. Improved varieties are needed with higher yield, resistance to diseases and insects, adaptation to mechanical harvesting, improved shelling and processing characteristics, increased market acceptability, enhanced nutritional and keeping properties, and greater consumer appeal.

The average yield of flaxseed is low and a practical way to increase average yields is needed urgently to reduce production costs and improve the economic production of linseed oil. Varieties are available that will produce up to three times the national average in Minnesota and the Dakotas when environmental factors are favorable. The effect of these factors separately and in combination needs extended exploration to provide sound production practices. Hybrid flax is a possibility and studies need to be made to determine an effective means of pollen transfer from male to female lines.

There is a continuing need for production and evaluation of improved breeding lines of castorbean to be used in the production of F_1 seed for commercial planting. Capsule mold is the major disease problem in areas of production. Inbred lines with resistance are being developed and need extensive testing for combining ability in hybrids.

The large requirement of hand labor to produce sesame has limited production severely. It will be necessary to breed improved indehiscent lines with higher yield, improved threshability and seed quality, resistance to disease, and adaptation to complete mechanical harvesting.

The most important problem in sunflower is the breeding of improved lines with resistance to diseases and insects and having high oil percentage in the seed. Rust, downy mildew, and Verticillium wilt are the most serious diseases. Resistance is available and is being incorporated in improved lines. Screening for resistance to the sunflower head moth indicates a high degree of resistance may be difficult to attain. However, apparent genetic differences appear available.

Research on crambe is new and much information is needed on areas of adaptation, evaluation of available germplasm, practical cultural practices, disease identification and control, and effects of environment on seed quality.

With tung, resistance to spring frosts or cold is needed. The solution may require new methods of management, or improved varieties. More information on spacing, nutrition, cultural practices, and variety testing is needed to enable more consistent and higher production at less cost.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving geneticists, pathologists, biochemists, physiologists, agronomists, and horticulturists engaged in both basic and applied research leading to the solution of growers' problems.

Safflower breeding, disease, and cultural research is carried on in cooperation with the Arizona, California, Nebraska, and Utah Agricultural Experiment Stations, and at Beltsville, Maryland.

Peanut breeding and variety evaluation research and peanut disease investigations are cooperative with the Georgia, North Carolina, Oklahoma, and Virginia Agricultural Experiment Stations. Disease, culture, seed physiology, and variety evaluation research are cooperative with the Alabama Agricultural Experiment Station. Peanut variety evaluation and seed physiology research are carried on at Beltsville, Maryland.

Flax research is conducted cooperatively with the Minnesota, North Dakota, and South Dakota Agricultural Experiment Stations and at the Southwestern Irrigation Field Station, Brawley, California.

Castorbean breeding, genetics, disease control, and cultural practices are conducted in cooperation with the Texas Agricultural Experiment Station.

Sesame research on breeding and evaluation is in cooperation with the Texas Agricultural Experiment Station and disease investigations are made at Beltsville, Maryland.

Sunflower breeding and genetics is conducted in cooperation with the Texas Agricultural Experiment Station. Disease studies are carried out at Beltsville, Maryland. A position for an agronomist has been established in cooperation with the North Dakota Agricultural Experiment Station to conduct research on breeding and cultural practices.

Crambe investigations are cooperative with the Nebraska, Texas, and Utah Agricultural Experiment Stations.

Tung research is carried on at one central field location at Bogalusa, Louisiana, with a field laboratory at Monticello, Florida. The work is cooperative with the experiment stations of Mississippi and Louisiana. Much of the field work and experimental plantings are at the Mississippi Experimental Tung Farm, Poplarville, Mississippi.

Extramural research includes the nature of resistance to safflower diseases being carried out under cooperative agreement with the California Agricultural Experiment Station. The structure of the safflower seed with particular reference to the pigmented layer (melanin) and other structures of the seed coat has been studied under cooperative agreement with the Arizona Agricultural Experiment Station.

Peanut mycotoxin research is conducted under contract with Georgia, North Carolina, Oklahoma, and Texas Agricultural Experiment Stations; under cooperative agreements with the Alabama, Georgia, Texas, and Virginia Agricultural Experiment Stations; and under a grant with the Minnesota Agricultural Experiment Station. Peanut gnotobiotic research is conducted under a grant with the Colorado Agricultural Experiment Station. Under cooperative agreements, research is conducted on peanut stunt virus with North Carolina and Virginia Agricultural Experiment Stations; on identification of genetic resistance in peanut germ plasm to southern corn rootworm with Georgia and North Carolina Agricultural Experiment Stations; and on identification of genetic resistance in peanuts to nematodes with the Oklahoma Agricultural Experiment Station. Research on range of genetic variability in tocopherols of diverse peanut germ plasm is being conducted under contract at Menlo Park, California.

The nature of resistance to flax rust is being investigated under contract with the North Dakota Agricultural Experiment Station. Studies of the effects of irradiation of flaxseed are being supported by contributed funds from the Atomic Energy Commission.

A PL 480 program has been initiated and preliminary results reported on a study of the resistance of safflower lines in the World Collection to insects and diseases. Peanut research is being conducted under four 5-year PL 480 research contracts: Three in India on range of genetic variability in chemical composition of seed in United States, and India's diverse peanut germ plasm; on physiology of cell particulates of plants grown on soil with wide range of salt content; on role of major mineral elements, particularly calcium, in metabolic activities of peanut and flax plants; and one in

Israel involving a study of the biology of the fungus Aspergillus flavus as it affects peanuts.

The Federal scientific effort devoted to research in this area totals 28.0 scientist man-years. Of this number 10.0 are devoted to breeding and genetics; 10.4 to diseases; 2.5 to variety evaluation; 4.5 to culture and physiology; and 0.6 to quality.

Extramural research conducted under contract, cooperative agreement, or grant totals 8.0 S.M.Y. of which 0.6 is devoted to breeding and genetics; 6.6 to diseases; 0.5 to variety evaluation; 0.1 to culture and physiology; and 0.2 to quality.

PROGRAM OF STATE EXPERIMENT STATIONS

The research effort of the State experiment stations in this area totals 26.3 scientist man-years.

PROGRESS--USDA AND COOPERATIVE PROGRAM

A. Breeding and Genetics

1. Safflower. An improved safflower line, 12295, has yielded about 10 percent more than Gila and Frio, leading commercial varieties in Arizona. In addition it is higher in oil percentage, is moderately resistant to rust, resistant to both high and low temperature isolates of Phytophthora root rot, and is more resistant to Verticillium wilt than Gila or Frio. It is anticipated 200 tons of seed will be available for release for 1967-68 planting.

Progress has been made in breeding agronomically acceptable thin hull lines to be used as females in producing F_1 hybrids. The yields of hybrids in 1967 in Arizona were not significantly better than those of the best commercial inbreds. This unexpected result may be due to few thin hull lines being available as female parents and the crosses used may not be the best available.

2. Peanut. Natural crossing. Evidence of uni-directional natural crossing, obtained by use of genetic markers over a period of 3 years, indicates a low level of natural outcrossing in peanuts at Holland, Virginia. Level varied with seasons and genotypes, with the latter maintaining relative positions from year to year. Overall average at Holland 1963-65 was 0.20 percent with a range among years and genotypes of 0.01 to 0.55 percent. At Tifton, Georgia in 1966 natural crossing averaged 3.08 percent for 2 field plantings of alternate hills of Pearl and Krinkle markers, both of which were included in Holland test in 1964 and 1965. In collaboration with Entomology Research Division evidence was obtained that thrips are not responsible for natural crossing in peanuts at Tifton, Georgia.

Search for genetic resistance to pests. Preliminary results at Tifton, in cooperation with Entomology Research Division, indicate that certain accessions of wild species of Arachis have a high degree of resistance to spider mites; that young larvae of the lesser cornstalk borer preferred young seedlings of certain genotypes of cultivated peanuts to others under greenhouse conditions; and that certain varieties and market types of cultivated peanuts were preferred to others for feeding by thrips and by corn earworm. In research under cooperative agreement at Tifton, Georgia, larvae of the southern corn rootworm survived differentially in preliminary tests when confined for feeding on freshly germinated seedlings of a wide range of genotypes of cultivated peanuts. In research under cooperative agreement in North Carolina 19 additional genotypes of cultivated peanuts have been found to be less preferred than susceptible standard commercial varieties to infestation and feeding by adults and larvae of southern corn rootworm under both field and laboratory conditions. In cooperative research at Stillwater, Oklahoma, genotypes of cultivated peanuts have reacted differentially to the northern rootknot nematode in tests under controlled conditions in greenhouse and growth chambers, but firm evidence of genetically usable resistance or tolerance to this pest in cultivated peanuts has not been obtained. Certain accessions of wild species of Arachis appeared highly resistant or immune to the northern rootknot nematode in strictly preliminary tests. In replicated field tests in Virginia all 304 genotypes of cultivated peanuts were found to be susceptible to peanut stunt. Certain genotypes appeared to be more adversely affected than others. In tests under controlled conditions in extramural research in North Carolina certain accessions of wild species of Arachis appeared to be immune to the peanut stunt virus. These suggestive results are encouraging, but evidence of a more critical nature will be required before we know whether the apparent immunity, resistance or tolerance of peanut genotypes to these pests, or an apparent nonpreference of insects for certain peanut genotypes, represents genetically usable resistance or tolerance that might be useful in peanut variety improvement.

3. Flax. New varieties. Two experimental flax varieties were increased for release to certified seed growers. A third line after two years of testing was high in yield, high in oil content and quality, had good tolerance to pasmo, and has multiple-gene resistance to rust.

Varietal mixtures. As an average for five years, mixtures of varieties have yielded more than varieties sown alone in those trials where seed yields tend to be low. Mixtures may have an advantage for commercial production because the greatest benefit was noted in trials where yields were close to the commercial acreage.

Tolerance to MCPA. Advanced breeding lines selected for tolerance to MCPA varied widely in reaction to the herbicide. A heavy rate of application - 4 times recommended rate - reduced the yield of sensitive lines by over 50 percent. The yield of tolerant lines was reduced by less than 25 percent. MCPA is widely used to control broad-leafed weeds in flax and

breeding lines tolerant to this herbicide will be a significant accomplishment. Average reduction in yield due to MCPA of varieties grown in weed-free nurseries at St. Paul, Minnesota, has been approximately 10 percent.

Iodine number of linseed oil. It has been known for many years that both high iodine number of the oil as well as oil content of the seed is associated with seed color. Isogenic lines with yellow seeds are usually higher in oil and iodine number than their brown-seeded counterparts. The D D gene has been shown to affect both flower and seed color in flax. Seventeen isogenic lines with the recessive d d allel average 15 points higher in iodine value than the brown-seeded (D D) isogenic lines.

4. Castorbean. Hybrid castorbeans. Early hybrid varieties continued to show superiority in yield over later hybrids and open-pollinated varieties in Texas yield trials. The newest commercial hybrid available, CNES-1 X Lynn, produced yields of over 3,000 pounds per acre compared with yields of 2,000 pounds of inbred varieties. Further improvement in breeding lines for hybrid production can be expected to be an important factor in increasing yields of castorbeans.

Composite Cross I. This composite cross was initiated to provide as great a diversity of germplasm as possible in dwarf internode plants. All introductions available were mechanically crossed with the dwarf type. In the F_2 and subsequent generations, the normal internode types have been eliminated. The cross is being used by commercial breeders as a source of new gene combinations. Success in developing increased variability is indicated by the high degree of natural crossing in Texas (up to 80 percent). Second round selection from this material has produced plants superior in earliness, plant type and indehiscence.

Female sterile. Two female sterile characters were observed in the field. Each was inherited as a simple recessive.

5. Sunflower. Hybrid sunflower. Hybrid sunflower seed for commercial planting is produced by using a line with low self-compatability as the female. The percentage of true crosses depends upon the degree of self-incompatability, abundance of pollen from the male parent, and effects of environmental factors not yet well understood. The percentage of actual hybrids resulting varies considerably, but at least 70 percent is necessary to insure significant yield increases.

High oil lines introduced from the USSR yielded from 66 to 87 percent as much seed as the variety T 56002, which contained only 50 to 60 percent hybrid seed. One of the introduced high oil lines, Peredovik-21, is known to be segregating for male sterility and resistance to both rust and Verticillium wilt. A cross of male-sterile Peredovik-21 X HA 20 was produced in Argentina for yield trials in 1967.

Male sterility. An acceptable source of male sterility is required for production of seed with a high degree of crossing for commercial planting. Four types of male sterility are under investigation. Each appears to be different genetically from the others.

6. Tung. Breeding for late blossoming and cold hardiness. Controlled pollinations in 49 parental combinations, in which the characters of late blossoming and cold resistance were stressed, yielded 2289 seeds. When resistance of terminal buds to forcing was investigated in a controlled environment, buds of BR-363, M-280, L-508, BR-576, and G-46 showed greatest relative resistance to forcing compared with 9 other clones and 2 standards. Under field conditions, BR-363 blossomed distinctly later than the standards, and the others named blossomed slightly to moderately later. A. montana-A. fordii hybrid selections compared rather favorably in oil content and refractive index with A. fordii selections.

B. Diseases

1. Safflower. Rust. Rust, particularly in the seedling stage, is the most important disease in the Interior Valley of California. Resistance is being incorporated into commercial varieties by the backcross method. Tests of a large number of varieties and breeding lines show that resistance to the foliage stage was accompanied by resistance in the seedling stage.

Rhizoctonia. The inbred line, Nebraska 4051, was shown to have a high degree of resistance to Rhizoctonia. Seedling resistance to Rhizoctonia is rare.

Fusarium. Results of pathogenicity tests with several isolates of Fusarium oxysporum f. carthami indicate the existence of two distinct pathogenic races in California. Twelve breeding lines each homozygous for resistance to the two races, were developed and sent to California for evaluation in naturally infested fields.

Verticillium. Preliminary studies indicate a moderate degree of resistance to Verticillium wilt. Observations of strip plantings in Arizona indicated a new line scheduled for release was superior to present commercial varieties.

2. Peanut. Stunt virus was widespread in peanuts in Virginia and North Carolina in 1966, but was severely destructive in only a few fields in Virginia and one field in North Carolina. The virus was found in plants of several other crops throughout North Carolina. It was prevalent in bean plantings in several counties in western North Carolina and eastern Tennessee. Sereological tests indicate that a single peanut plant in a 1966 experimental planting at Experiment, Georgia, well outside the principal peanut commercial production area, was infected with stunt. A newly recognized virus disease of beans in the State of Washington is caused by a virus that gives the same sereological test reaction as the peanut stunt

virus. The peanut stunt virus appears to be different from all known viruses, but has certain characteristics that indicate a similarity to cucumber mosaic virus. Perennial clovers, particularly white clover, were found to be a major reservoir of stunt virus in the vicinity of peanut fields affected with stunt in Virginia and North Carolina. At least 3 species of aphids were found capable of transmitting the non-persistent virus under controlled conditions. The cowpea aphid is strongly suspect as a vector of the virus under field conditions in Virginia and North Carolina. Stunt virus does not kill peanut plants, but drastically reduced yield and market quality of large-seeded Virginia type peanuts in 3 commercial fields in Virginia in 1966. Severely stunted plants produced no marketable fruit; pods and seed were very sharply reduced in size and severely distorted in shape. Plants that were less severely diseased produced some marketable fruit, but many of the pods and seed were substandard in size and distorted in shape. The virus was found to be seed transmitted in peanuts at a low level - 0.20 percent in seed from severely diseased plants that passed through an 18/64-inch screen; 0.02 percent in seed from moderately diseased plants that passed through an 18/64-inch screen; and zero for 8,877 seed from moderately diseased plants that rode an 18/64-inch screen.

Evidence from peanut pod breakdown (formerly called pod rot) studies at Holland, Virginia, indicates that a low calcium-potassium ratio tends to predispose peanut fruits to pod breakdown. Evidence that meets Koch's postulates shows Pythium spp. to cause typical peanut pod breakdown. Results at Holland using recently-developed techniques suggest that Pythium spp. may play a prominent role in causing peanut X-wilt, which has been present for many years and assumed serious proportions in Virginia late in the 1966 season. A form of Botrytis blight which began at the soil line caused widespread damage to peanuts in Virginia late in the 1966 season. This form of the disease can be more destructive than the usual form which begins at the growing tip of the branches. Preliminary results indicate that this "soil-line" form of Botrytis blight is caused initially by an organism other than Botrytis spp.

Pod and seed fungi. Results from a belt-wide survey of peanut pod and seed microflora in 1966 by our own staff and under contracts and cooperative agreements with Agricultural experiment stations in Alabama, Georgia, North Carolina, Oklahoma, Texas and Virginia, confirm results for 1965 in indicating that pods and seed support a rich varied fungal microflora, and that initial infection may occur soon after the pegs enter the soil and pod enlargement begins. Under conditions which usually prevail these seed-invading fungi soon become quiescent and remain so. Preliminary results of tests at the University of Minnesota, in which representative isolates of these peanut fruit fungi were cultured on autoclaved corn and the resultant material was then fed to rats, indicate that many fungi other than Aspergillus flavus isolated from peanuts have a potential for production of metabolites that are toxic to warm-blooded animals. However, much additional carefully conducted research will be required before we know if the capability of these fungi to produce toxic substances has implications for peanuts

or other agricultural commodities as they are now grown, handled and used for food and feed.

A. flavus is a persistent member of the soil microflora of peanut fields in all major production areas, and consequently a potential exists in all major producing areas for invasion of peanut pods by this fungus. Peanut pods and seed may become infected with A. flavus long before digging. Level of infection prior to digging has varied from none or occasional, up to 50 percent. Prevalence usually increased during curing, strikingly so at times.

We found no consistent association of occurrence or prevalence of A. flavus in peanut shells and seed with any variety, area of production, crop year, or soil type. We investigated a few crop rotation practices; several cover crops; various fertilizer, landplaster, and irrigation regimes; several commonly used soil fungicides or other fungicides applied post-digging; different types of land preparation; and found none of these to have an obvious influence on occurrence or prevalence of A. flavus in peanut shells and seed.

A high proportion of the isolates of A. flavus from all production areas were capable of producing aflatoxin. However, aflatoxin was found only rarely in peanut fruits prior to or at digging. Some samples of peanuts from post-digging experiments in all States were found to be contaminated with aflatoxin.

Conditions under which these experimental peanuts were cured strongly influenced the development of aflatoxin in shells and seed. Prompt steady drying to a seed moisture level of 7 or 8 percent within 3 to 5 days was highly effective in suppressing the development of A. flavus and contamination of seed by aflatoxin. A prolonged period of drying (10 days to 2 weeks), or a major interruption (2 to 4 days), or reversal by rain once drying was well under way, was conducive to development of A. flavus and contamination of seed with aflatoxin if temperature conditions were favorable for development of the fungus while seed moisture level was between about 30 and 15 percent. Mechanical injury of pods and seed by combine or other means appeared to make seed more susceptible to invasion by A. flavus and contamination by aflatoxin, under conditions favorable for aflatoxin production.

Results of PL 480 research in Israel, cosponsored by Market Quality Research Division, indicate that the peanut microflora and mycotoxin problems in that country are similar to those in the United States. Their findings substantiate results obtained in this country.

Certain strictly preliminary results suggest the possibility that not all varieties of peanuts are equally susceptible to invasion of shells, seedcoats, and cotyledons by A. flavus, and/or to the production of aflatoxin in seed invaded by the fungus. More critical tests are needed before a claim can be made for genetic resistance to A. flavus or aflatoxin production.

We have failed to confirm a recently published report by scientists in India that seed of USA peanut Plant Introduction 246388 are resistant to the development of aflatoxin. When Georgia-grown seed of PI 246388 were inoculated with an aflatoxin-producing strain of A. flavus and incubated under conditions favorable to fungus growth and aflatoxin development, appreciable levels of aflatoxin were found in the seed in 3 tests. Tests with this peanut are continuing, and an exchange of seed of it with the Indian scientists has been proposed through the New Crops Research Branch.

Weather advisory service for peanut leafspots control. As a result of cooperative research in Georgia involving the Environmental Science Services Administration, Weather Bureau, U.S. Department of Commerce over a period of several years, peanut growers in Georgia, Florida and Alabama are being informed by the Weather Bureau's Public Service and Agricultural Weather Teletype Network weather advisory releases to local radio and TV stations of meteorological conditions that are highly conducive to rapid development and spread of peanut leafspots during the 1967 growing season. Research results indicate that peanut leafspots can be controlled more effectively when application of fungicides is based on weather conditions than when based on the calendar.

3. Flax. Rust. Flax rust was present in only a small area in North Dakota and in Texas where susceptible varieties were sown. The build-up of resistance genes in Bison-like varieties has been successful. Lines with 3 genes have been tested and found satisfactory for commercial production if needed. It is unlikely that new races capable of attacking all 3 genes can develop by mutation.

4. Castorbean. Botrytis capsule mold. Work on selection within 3 breeding lines of outstanding resistance to capsule mold was completed at Beltsville. Seed was increased and sent to Texas for field evaluation.

C. Varietal Evaluation

1. Safflower. Four commercial varieties and 3 breeding lines were grown under irrigation at 9 locations in 1966 and at 8 locations without irrigation. Average yields ranged from a low of 1110 pounds at Artesia, New Mexico to 4777 pounds at Union, Oregon. The breeding line, 12295, considered for release in Arizona, has average 10 percent more seed yield than Frio, the leading commercial variety, has greater resistance to Phytophthora root rot and Verticillium wilt, and slightly higher oil percentage. This line has not proved superior to Frio outside Arizona.

2. Flax. Performance data were obtained from 29 yield trials of leading commercial varieties and breeding lines in the United States and Canada. One experimental line, C.I. 2444, yielded 14 percent more than the Redwood check. As an average of 22 trials, C.I. 2444 was 0.6 percent higher in oil and equal in iodine number. This line has two genes for rust resistance which could be a decided advantage if new races were to appear. It is also more tolerant of pasmo and has satisfactory wilt resistance. It is expected breeders' seed will be released in 1968.

3. Crambe. Research on crambe was limited in scope in 1966. Eight varieties grown under irrigation at Mitchell, Nebraska, averaged 3400 pounds seed per acre with an average oil content of 22.0 percent in the undecorticated seed. The same varieties yielded an average of 750 pounds per acre with an average oil content of 21.4 percent on non-irrigated land at Dalton, Nebraska. Both trials had been severely damaged by hail shortly after emergence, but made remarkable recovery.

D. Culture and Physiology

1. Safflower. Nitrogen applications of 75 or 150 pounds per acre to safflower at Mesa, Arizona, increased the yield from 1242 pounds to 3131 and 3737 pounds, respectively. With a cost of 13¢ per unit for nitrogen and $2.50 per acre for application the additional net profit was $72.80 and $90.32 per acre when nitrogen was applied at 75 or 150 pounds per acre.

2. Flax. Flax plants have demonstrated ability to compensate for stand loss up to 6 weeks of age. An average yield reduction of only 8 percent resulted by removing half the plants at 6 weeks. At 8 weeks the loss was 44 percent.

Effect of day length. Under controlled conditions in a growth chamber, flax plants grown under 19 hours of light produced more bolls, larger seed with higher oil content and iodine number than plants grown under 13 hours of light. This confirms observations that as flax is grown farther north under longer days, both oil percentage and iodine number tend to increase.

Defoliation. The lower leaves on field-grown flax plants tend to dry up about flowering time. This has caused some concern about a possible reduction in yield. Defoliation trials under controlled conditions at time of flowering demonstrated that a substantial portion of nutrients used by the developing seed is supplied by non-leafy green tissues such as the boll, pedicel, stem, and perhaps even the embryo. Only complete removal of leafy tissue reduced seed yield significantly. Complete defoliation resulted in a 30 to 50 percent reduction in both seed and oil yield. On the other hand, iodine values were increased significantly by any treatment that included removal of the sepals.

Lipid metabolism in flaxseed. The major initial steps in the metabolism of linoleic acid in flaxseed are (a) linoleic acid is acted on by lipoxidase to form a diene hydroperoxide; (b) the diene hydroperoxide is converted by a hydroperoxide isomerase to corresponding keto-hydroxy derivatives: 12-keto-13-hydroxy octadec-*cis*-9-enoic acid and 9-hydroxy-10-keto-octadec-*cis*-12-enoic acid in a ratio of 19:1.

The newly-identified enzyme hydroperoxide isomerase was detected in crude extracts of barley and wheat germ, and in partially purified extracts of soybean, pea, and alfalfa seedlings. This suggests the enzyme may be widely distributed in plants and may play an important role in the oxidative

metabolism of linoleic and possibly linolenic acid.

3. Tung. Chemical protection against cold injury and frost. Fourteen chemicals retarded the development of tung buds to varying degrees when used on buds, on abscised shoots, forced in a humid chamber in the laboratory.

Thiouracil at 500, 1500, or 3500 ppm retarded the buds when applied February 21 and repeated March 7, or on March 20 in a single application. However, the set of tung fruit was reduced by the treatments that retarded the buds as much as one week.

Mineral nutrition. Lithium was readily absorbed and translocated to all parts of the plant and could serve as an indicator element if used at non-toxic rates.

Seed germination. Slightly premature tung seed germinated readily after being dried, then refrigerated, and this technique may be used to reduce the time from seed to seed in the breeding program.

Chemical control of shoot growth. New shoot growth from otherwise comparable shoots of the preceding season was greater from shoots with 2 or less fruit than from shoots with 3 or 4 fruit. In general, very few shoots grew on terminals having 5 or more fruit, and they were small.

Potassium gibberellate stimulated number and length of shoots and could increase the induction of pistillate flowers by increasing the number of terminal buds. N-dimethylaminosuccinamic acid retarded shoot growth.

Orchard renewal. The early renewal of production by moderately pruning trees is encouraging.

The productive life of the trees may be extended with no significant loss of income due to pruning. Eventually, complete removal of old trees and replanting may prove most profitable.

Fertilizers and soil management. Now that the use of synthetic fertilizers, which do not contain some essential elements, is the predominate practice, information about Ca, Mg, and S in tung orchard management has become important.

Weed growth was effectively inhibited about 4 months by broadcast application of 5 pounds of simazine per acre in an orchard after the last cultivation, thus preventing weed interference with mechanical harvest.

E. Quality

1. Peanut. In contract research, seed of Virginia botanical type peanuts that are generally comparatively low in linoleic acid have been found to be substantially higher in alpha and gamma tocopherol and total tocopherols than seed of Spanish and Valencia type peanuts which generally are comparatively high in linoleic acid. Several genotypes of the Virginia type that produce seed that are high in linoleic acid are high also in tocopherols.

Full sunlight impaired quality of cured peanuts. In Alabama in research in cooperation with Environmental Science Services Administration, Weather Bureau, U.S. Department of Commerce, exposure of peanut pods to full sunlight during curing in a thin layer on a flat surface in 1963-1965 seriously impaired rapidity of germination and total germination of immature seed. Curing in full sunlight to average seed moisture levels of 7 to 9 percent significantly increased percentage of seed that split on shelling, and two years out of three reduced germination of mature seed and impaired the flavor of roasted mature seed, when compared to curing in one-half sunlight or under controlled conditions with forced circulation of ambient air.

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RESEARCH ON WEEDS AND NEMATODES
Crops Research Division, ARS

Problem. In spite of the best efforts to control weeds, today they still constitute one of the major items in the production costs in food, feed, and fiber crops. Weeds reduce crop yields, efficiency of land uses, crop and livestock quality, effectiveness of water management, and gross losses in human efficiency. Cost of controlling weeds and losses from failing to control them are borne directly or indirectly by all facets of private and personal life. The problem of herbicide residues that result from treating crops or the soil in a previous season causing damage or occurrence in a second crop in a rotation with a treated one is becoming increasingly serious. Current information is not adequate to develop herbicide-crop rotations that prevent the accumulation of herbicide residues in soils and prevent recurrence of residues in food and water. The introduction of new and powerful chemical tools and the prospect of broader utilization of biological control agents open new horizons for productive research designed to solve our nation's weed problems.

Nematodes attack all crop plants, but cause varying damage and crop losses, depending on the nematode, crop, and environmental conditions. Most plant-parasitic nematodes infect roots and other underground parts of plants but some attack bulbs, stems, leaves, and flowers. Damage initiated by nematodes is often extended by bacteria, fungi, and viruses. Damage can be reduced by use of varieties resistant to nematodes, but only a relatively few are available. Development of resistant varieties is a time-consuming task and does not completely protect the crop because multiple nematode resistance is difficult to attain and is lacking in all varieties thus far developed. Crop rotations have been devised to reduce some of our more important nematode problems but rotations rarely fit modern management practices, or may be uneconomical. While naturally-occurring biological agents undoubtedly have a great influence on nematode populations, manipulation and use of these principles for economic control is not yet practical. Great advances have been made in chemical control but use of nematocides on many crops is not economically feasible. More effective and cheaper nematocides and improved methods of application are needed.

USDA AND COOPERATIVE PROGRAM

Much of the weed control research in the Department is cooperative with State Experiment Stations, other Federal agencies, industry and certain private groups, and is cross commodity in nature. Of the total effort, 4.2 SMY's are specifically directed to weed control in oilseeds and peanuts. Research at Urbana, Illinois, pertains to the effects of soybean, corn, wheat-herbicide rotations on ecological changes in weed populations and on the fate of soil-applied herbicides and at Madison, Wisconsin, on the effects of synthetic chemical stimulants and on

principles and practices for weed control in soybeans.

The Department has a long-term, continuing program of basic and applied research on various phases of nematology. In the past few years, as State nematology programs have developed, there has been increased emphasis on basic research in the Department's program. Fundamental research on nematode taxonomy, pathology, ecology, and physiology is located at Beltsville, Maryland. In addition, fifteen field stations combine applied and basic research approaches to solve nematode problems on various crops. Research on nematodes affecting oilseeds and peanuts is located at Urbana, Illinois; Auburn, Alabama; Tifton, Georgia; Raleigh, North Carolina; and Jackson, Tennessee. The work at all field stations is in cooperation with the respective State Agricultural Experiment Stations.

The Federal intramural program devoted to nematology research totaled 26.0 scientist man-years. Of this, 7.8 were devoted to basic research on nematodes; 3.8 to oilseeds and peanuts.

The Federal intramural program devoted to nematology research in F.Y. 1967 totaled 5.0 scientist man-years. Of this, 3.0 were devoted to basic research on nematodes and 1.6 to soybeans.

PROGRESS - USDA AND COOPERATIVE PROGRAMS

A. Weed Control

1. Soybeans

(a) Physiology and Ecology of Soybeans and Weeds. Initial results indicated that soybeans stimulate late-season nitrate reductase activity in pigweed and foxtail. Adding nitrogen fertilizer to field plots did not affect the yields of soybeans grown alone but adding nitrogen resulted in greater decreases in yield by weed competition when soybeans were grown with either foxtail or pigweed. It appears that weeds would be more detrimental to soybeans in fields where nitrogen levels were high and this knowledge, when confirmed, may lead to improved fertilization management in rotations involving soybeans.

In Illinois, early-season protection of soybeans against weed competition, followed by normal cultivation, resulted in maximum yields and light infestations of weeds in the latter part of the season. Cultivation of trifluralin-treated soybean plots in Illinois increased the yield as compared with noncultivated plots. In the absence of cultivation, jimsonweed and velvetleaf are believed to have reduced yields. These weeds are not effectively controlled by trifluralin.

In Illinois, the affinity of phosphate for the absorption site in roots appeared to follow in the order of soybeans, morning glory, and foxtail; while the turnover rate of phosphorus at the absorption site follows the reverse order. Calcium enhanced phosphate absorption in all three species and prompted phosphate transport to shoots in morning glory.

(b) Control of Johnsongrass in Soybeans. Initial year results in contract research in Missouri indicates that fall-applied trifluralin may be a valuable component in systems of control of established johnsongrass in soybeans. Fall-applied trifluralin, combined with conventional cultural and herbicide treatments in the following spring and summer, provided excellent control of established johnsongrass. The yield of soybeans was higher than with systems in which fall-applied trifluralin was omitted.

In Mississippi, a new compound (CP-52089) was as effective as dalapon for control of perennial johnsongrass. Repeated preplanting applications of trifluralin over a two-year period provided excellent control of johnsongrass in soybeans from rhizomes. Different ecotypes of johnsongrass responded differently to foliar applications of dalapon and MSMA. The control of individual ecotypes was affected by rate of nitrogen fertilization.

(c) Control of Annual Weeds in Soybeans. Research in Missisiippi indicates that DNBP is safe and effective for postemergence control of several troublesome broadleaf weeds in soybeans. Laterally directed sprays of linuron, applied to basal portions of crop and weeds, effectively control sesbania plants 5 to 7 feet tall without significant injury to the soybeans. Cross cultivation again controlled tall-growing broadleaf weeds effectively on soybeans. The use of herbicides to control weeds in previously prepared seedbeds in lieu of preplanting cultivation provided good control of weeds with a high degree of tolerance of soybeans.

(d) Control of Weeds in Soybeans with Postemergence Injections of Vernolate. Preplanting placement of vernolate in bands beneath the soil surface through the use of modified sweeps and postemergence injections of vernolate in the soil, controlled nutsedge and annual weeds in soybeans without significant injury to the soybeans. Several of the specific treatments caused little or no injury to soybeans in Georgia and the techniques appeared useful for controlling weeds in soybeans.

(e) Subsurface Application of Herbicides for Control of Weeds in Peanuts. In Georgia, placement of the herbicide vernolate in subsurface bands 4 inches beneath the soil surface and placement by certain injection procedures produced better control of weeds and resulted in higher yields than did application by incorporation techniques currently registered and used by farmers. Herbicide injectors spaced 3 inches apart were more efficient in controlling weeds with vernolate than injectors spaced 4 or 5 inches apart. Injections either 2 or 4 inches deep were consistently more effective than injections at 6 inches below the soil surface.

(f) Control of Weeds in Safflower. Contrary to previous results, post-emergence applications of diuron in safflower reduced seed yields in Arizona. Prometryne and fluometuron controlled annual weeds effectively without adverse effects on yields of safflower in initial evaluations.

B. Nematode Control

1. Peanuts

Greenhouse and field studies during the past two years have not established conclusively that nematodes increase aflatoxins in peanuts. However, the data does suggest that root-knot nematodes (M. arenaria) are more likely involved in increase of Aspergillus flavus than root-lesion nematodes (P. brachyurus). Tests to date do show that root-knot nematodes greatly increase numbers of Aspergillus niger, Schlerotium bataticola, and total fungi in peanut shells and pegs. Field studies at Tifton, Georgia, showed that Virginia Bunch 67 was less susceptible to attack and allowed less reproduction of P. brachyurus than Florigiant, Argentine, Starr, and Georgia 186-28 peanuts.

2. Soybeans

In the southeastern Coastal Plains, sting nematodes (B. longicaudatus) pose a major threat to soybean production. To locate possible sources of resistance, 57 varieties or advanced screening lines were rated for nematode host susceptibility at Charleston, South Carolina; eight were found containing at least moderate tolerance. These lines all contain PI 1613453 germ plasm. In Louisiana, 14 soybean varieties were tested for resistance to Louisiana populations of M. incognita and Rotylenchulus reniformis. None showed appreciable resistance or tolerance to the reniform nematode, and the order of resistance to Louisiana root-knot populations was Bienville, Hill, Jackson, Pelican, and Bragg. In Tennessee, 12 farms were selected on a basis of a recent history of soybean-cyst nematode infection for planting of resistant soybeans. The farmers planted the new resistant bean D63-7320 in replicated tests with their usual non-resistant variety. Populations ranged from low to high in the various fields. Average yields were increased 12.45 bu. per acre or about $43.26. If these figures are applied to the two million known acres infected with this nematode in the U. S., the national potential loss is approximately 15,000,000 bushels.

Seed of D63-7320, which is resistant to the soybean-cyst nematode, was increased in 1966 and 1967 and will be available to growers for the 1968 planting as a new variety, Dyer, in maturity Group 5. Other studies indicate that Dyer, like the previously studied resistant variety, Pickett, are highly resistant to all populations of soybean-cyst nematode except those that occur in Holland, Virginia, and Elizabeth City, North Carolina. However, tests of new crosses indicate that high-level resistance to these populations can be developed by improving present lines. In a three-year

study, resistance-breaking biotypes of the soybean-cyst nematode have not been detected indicating that present varieties may hold up for many years, especially if some rotation is practiced. Results of a four-year field study in Tennessee clearly show that use of resistant beans reduce populations of soybean-cyst nematodes; likewise, there was no significant hazardous increase even when a moderately resistant variety, such as Illsoy, is grown. Nonresistant varieties greatly increase populations.

Extramural research under Cooperative Agreement at Auburn University has shown from a survey of nematodes infesting 28 major soybean-producing counties in Alabama, Florida, and Georgia, that 11 important genera of plant-parasitic nematodes were associated with crop damage. Soil populations often exceeded 2,000 nematodes per pint of soil in fields where stunted chlorotic plants with diseased roots occurred. Root-knot and sting nematodes were more common in sandy soils while spiral, root-lesion, and pin nematodes were most common in the heavier soils. In severely infested fields, crop losses approached 40 percent.

Extramural research at North Carolina State University showed that high soil concentrations of ammonium nitrate decreased populations of soybean-cyst nematodes more than sodium nitrate; also, high soil levels of calcium retarded the development of root-knot nematodes on soybeans.

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SOYBEAN AND PEANUT INSECTS
Entomology Research Division, ARS

Problem. Soybeans and peanuts are severely damaged by several insect pests in the different areas where these crops are grown in the United States. The increasing concentration of acreage in soybeans and possibly the adaptation of native insects to this crop are resulting in more varied and more serious insect problems. Basic information is lacking on the biology of many of these pests and on the extent and nature of damage they cause to these crops. Such information is needed to serve as a foundation for the development of satisfactory control methods. Some insecticides, although highly effective in controlling insects on soybeans and peanuts, cannot be used because they leave harmful residues. Further, certain insects have developed resistance to insecticides that are currently recommended. For the immediate future, there should be continued effort to find insecticides that can be used safely and that give effective, economical control of all species of insects attacking these crops. For more desirable long-range solutions to the problems, more attention needs to be given to nonchemical control methods, with particular emphasis on insect-resistant crop varieties and biological control agents and the exploration of new chemical approaches such as attractants and repellents.

USDA AND COOPERATIVE PROGRAM

The Department has a limited program involving basic and applied research on insect problems of peanuts and soybeans directed toward developing efficient and economical control methods. The program is cooperative with State and Federal entomologists, agronomists, and chemists. Studies on soybean insects are conducted at Columbia, Mo., and on soybean and peanut insects at Tifton, Ga., in cooperation with the Missouri and Georgia Experiment Stations. Some oilseed crops are evaluated for resistance to insects at the Regional Plant Introduction Station at Ames, Iowa.

Additional research is conducted through two grants and two cooperative agreements with State Experiment Stations.

The Federal scientific effort devoted to research in this area totals 2.5 scientist man-years. Of this number 0.5 man-year is devoted to basic biology; 0.3 to insecticidal control; and 0.1 to biological control; 1.4 to varietal evaluation for insect resistance; 0.1 to insect vectors of diseases; and 0.1 to program leadership.

In addition, Federal support of research in this area conducted under grants provides a total of 1.0 scientist man-year. Of this 0.2 man-year is devoted to research on basic biology; 0.2 to insecticidal control, 0.4 man-year to varietal resistance, and 0.2 man-year to insect vectors.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 9.0 professional man-years is devoted to this area of research.

PROGRESS -- USDA AND COOPERATIVE PROGRAM

A. Basic Biology, Physiology, and Nutrition

1. Soybean Insects. Studies at Columbia, Mo., on the comparative development of the corn earworm, Heliothis zea, on soybeans and corn showed that pupae from larvae developing on soybeans were significantly lighter (330 mg) than those developing on corn (473 mg). The rate of gain of the larvae was greater on corn than on soybeans.

In oviposition tests at Columbia, Mo., the corn earworm showed a preference for corn. Out of a total of 644 eggs, 575 were deposited on corn and only 69 were deposited on soybeans when both plants were available for oviposition. There was no indication of a biotype which either preferred soybeans for oviposition or developed on soybeans as well as on corn. It was shown, however, that the corn earworm can maintain itself on soybeans.

At Columbia in cage tests designed to determine the density of corn earworm larvae required to cause economic damage in soybeans, treatments consisting of 0, 3, 6, 12, and 24 second instar larvae per plant were replicated 8 times. Significant differences in earworm damage were not apparent until the density reached about 3 larvae per plant.

In cage tests at Columbia adult bean leaf beetles, at densities as high as 16 beetles per plant, caused only significant differences in yield of Harosoy soybeans.

In cage tests at Columbia infesting soybeans with 0, 5, or 10 broadheaded bugs, Alydus pilosulus, per plant, caused no reduction in the total number of seeds produced. However, the mean weight of beans produced was significantly greater in the uninfested cages. There was a highly significant decrease in the size of beans from the infested plants and the damaged beans averaged about 25% lighter. In cages with 5 bugs per plant 41.6% of the seeds were damaged and in cages with 10 bugs per plant 57.3% of the beans were damaged. In cages with no bugs only 2.8% of the seeds were damaged. Subsequent examination of the damaged beans bacteriologically showed the presence of the yeast spot disease organism.

A cooperative agreement was recently initiated at Mississippi State University to study the biology and control of soybean insects particularly the pod and foliage feeders and determine the residues resulting from insecticide applications.

2. Peanut Insects. At Tifton, Ga., artificially infesting field-grown peanut plants with lesser cornstalk borer eggs showed that the larvae

damage the plants at ground level, pods, and pegs, and that the amount of damage was associated with infestation level. This study provided information for separating lesser cornstalk borer larval feeding damage from that of a complex of other insects infesting peanuts.

Investigations at Tifton showed that development of lesser cornstalk borer eggs did not occur at 0.5° C and 10.0° C. At 18° C hatch was complete in approximately 428 hours. At 33° C hatch was complete in 52 hours. At 36.5° C approximately 34% of eggs hatched in less than 48 hours, but approximately 8% hatched as late as 72 hours and approximately 34% failed to hatch.

3. Sunflower Insects. A grant was recently negotiated with the Texas Experiment Station to study the biology and control of the sunflower moth, a very serious pest of this oilseed crop.

B. Insecticidal and Cultural Control

1. Soybean Insects. At Columbia, Mo., soybeans treated with DDT+parathion yielded 38.4 bushels compared to 22.1 bushels in the untreated check. Plots treated with carbaryl yielded only 12.3 bushels per acre due to phytotoxicity and severe spider mite damage. The DDT+parathion plots continued to yield better than the check in later maturing varieties but differences were not marked. The DDT+parathion treated plots in varieties of two maturity dates had significantly higher seed quality than the untreated beans.

At Columbia carbaryl at two pounds per acre and methyl-parathion at one pound and a mixture containing one pound DDT plus two pounds toxaphene were applied by air to control corn earworm larvae on soybeans. After 24 hours methyl-parathion showed a 50.8% reduction in earworms, and after three days, 76.3%. DDT+toxaphene mixture and carbaryl controlled only 27.3% and 41.7% of the larvae at 24 hours, but five days later control by these materials was 85.4% and 89.1%, respectively.

Excellent control of thrips was obtained at Columbia using several insecticides including carbaryl, Azodrin, TDE, DDT+parathion, and others. The yield of soybeans was not significantly greater in treated plots.

C. Insecticide Residue Determinations

1. Peanuts. At Beltsville, Md., 25 samples of peanut butter from processing plants in different areas were analyzed for dieldrin residues. No dieldrin residues were found in any of the samples.

D. Evaluation of Equipment for Insect Detection and Control

1. Soybean Insects. At Columbia, Mo., an experimental ultra low volume ground applicator was tested. This applicator consisted of three spinning-cone distributors with three 6" fans mounted behind. The insecticide was metered to the cone distributor by a metering pump and the apparatus was powered by a gasoline driven alternator. The machine was mounted on a two-wheeled bicycle cart. Tests against the green stink bug and the corn earworm indicated that this method of application may be useful in the control of soybean insects.

E. Varietal Evaluation for Insect Resistance

1. Soybean Insects. At Columbia evaluation of soybeans for resistance to green stink bug damage showed that there was a significant difference between many of the varieties. Although differences were observed, the lines showing the least damage did not differe significantly from the variety Harasoy-63.

2. Peanut Insects.

At Tifton, Ga., host plant resistance investigations in 1965 and 1966 with 14 advanced peanut lines showed that differential damage by some insects occurred among plant types and varieties. Thrips damage to Runner and Virginia type plants in 1966 was significantly higher than among Spanish type plants. The same relationship was also recorded in 1965. Foliage feeding damage by the corn earworm in both seasons was significantly higher among Spanish than among Runner and Virginia type plants. Non-preference to larval leaf ragging was indicated for the varieties Runner Check, Virginia Bunch 67, Florigiant, Fla. Exp. 416, and Ga. 119-20. Varieties Starr, Argentine, Spanish Check, and NC-2 indicated some resistance to thrips.

At Tifton 54 wild peanut varieties, maintained as germ plasm sources for genetic studies, were subjected to mites, Tetranychus tumidellus, in the greenhouse. Through a 5-month period, a high level of tolerance to mite infestation was exhibited by 52 of the varieties.

Two varieties (Tifton entries A83 and A132) were killed by mites while five varieties (Tifton entries A22, A78, A79, A147, and A148) exhibited a high level of resistance.

At Tifton an initial test was carried out in the greenhouse with peanut seedlings to determine the feasibility of using the flat-planted seedling survival technique for rapid mass varietal resistance screening. Of 106 peanut lines artificially infested with lesser cornstalk borer eggs, approximately 15 entries showed a high level of seedling survival.

In 1967 resistance to thrips was investigated in the field among 343 peanut lines and two indicated a high level of resistance.

Under a research grant with Oklahoma State University, significant differences in thrips damage were observed among 481 peanut lines tested in the field. Sixty-one entries were selected as possible resistants. It was found that rating thrips damage on the last unfurled leaf on 20 plants per plot gave results comparable to those obtained by rating all damaged leaves on 20 plants.

3. Other Oilseed Crops. Species of a flea beetle, Phyllotreta sp., caused injury to plant introductions of the oilseed crops Crambe spp. and Brassica spp. at Ames, Iowa. The injury was typical of flea beetle feeding and consisted of small holes eaten in the leaves. Brassica campestris and B. napus were heavily fed on and one accession of B. napus had an average of 26.0 feeding scars per leaf. B. hirta showed the least injury of any of the Brassica spp. and one accession, PI 312849, had 0 feeding scars in a random count of 100 leaves.

Crambe abyssinica and C. hispanica showed considerably less flea beetle injury than did either B. campestris or B. napus. There appears to be sufficient resistance in C. abyssinica to this flea beetle that it should not become a serious problem if crambe becomes a major crop. However, it is of importance to note that several accessions of crambe do not possess this resistance, especially PI 281732. If agronomically desirable characteristics from such accessions are incorporated into improved varieties of crambe without regard to flea beetle resistance, susceptibility to the insect could be transferred also.

F. Insect Vectors of Diseases

1. Peanuts. Research under a grant to the University of North Carolina showed that peanut plants infected with peanut stunt were often in fields adjacent to pastures where clover was infected with stunt virus. This suggests that viruliferous insects spread the disease. The lowest incidence of peanut stunt was found in plots treated with phorate at planting and diazinon at pegging time. Plots treated early with malathion contained more infected plants than untreated plots possibly because the partial insect control obtained kept the plants more attractive for some insects.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAM

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Insect Vectors of Diseases

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OILSEED AND PEANUT PRODUCTION, HARVESTING AND PROCESSING EQUIPMENT
Agricultural Engineering Research Division, ARS

Problem. Many pests, plant diseases, weeds, insects and nematodes attack oilseeds and peanuts. Every method to control or eradicate any of these pests requires some type of equipment, be it a small chemical sprayer or a giant bulldozer. Thus, equipment to control a wide variety of pests on a wide variety of crops is required. This requirement is partially met by the sprayers, cultivators, dusters, and soil injection equipment now available. However, mechanical cultivation does not always produce satisfactory weed control. It is also time consuming and costly. It is believed that with sprayers and dusters now used, often no more than 10 to 20 percent of the chemical goes onto the plant. Methods of applying nematocides in the soil do not always result in uniform nematode control and untreated soil below the treated zone, in untreated pockets, and at the soil surface, provides sources for quick reinfestation.

There is need for improved methods of much greater efficiency for applying pesticides to plants and the soil. This implies a need for considerable fundamental study of small particle behavior, of radically new methods of applying chemicals, and of the movement of liquid and gaseous chemicals in the soil. The sales of present equipment are not great enough, nor are the manufacturers large enough, to permit industry to make a very great investment for research in this field.

The cost of harvesting and farm handling of most crops is the major expense of production, often equal to over half of the total returns to the producer from the sale of the product. In addition, supply and adequacy of manpower for these operations are becoming progressively less satisfactory.

The value of farm products is influenced by the methods, techniques, and equipment used on farms for the initial preparation for market. Likewise, the profitability of an enterprise depends on the efficiency in the use of labor and equipment, preservation of quality, and prevention of spoilage and damage from mechanical handling. While considerable information has already been obtained for the development of processes such as drying and separation, basic and more precise information must be developed for these and other processes in order to achieve further progress. The underlying principles that pertain to the cleaning and drying of different crops, curing of peanuts, and sorting need to be determined.

Production of many crops is hampered by poor, slow, or nonuniform emergence of seedlings after the seed is planted. Some electrical treatments have been found to accelerate germination and seedling emergence. If emergence in the field can be speeded up and better uniformity obtained, weed control can be much more effective, with resulting increased efficiency in production of crops. Treatments also increase the percentage of germination for some seeds and would therefore enable the establishment of good stands

with lower investments for seed. Further, uniform emergence tends toward more uniform saturation with increased practicability of once-over harvest programs.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving agricultural engineers engaged in both basic and applied research on the engineering phases of crop harvesting and handling (3.7 SMY); on crop preparation and farm processing (0.2 SMY tung nut processing -- 1.6 SMY peanut curing); crop pest control techniques and equipment (1.3 SMY weed control in soybeans): and on the effects of electric glow-discharge radiation on seeds.

Research on oilsedds and peanut harvesting equipment and methods is cooperative with the experiment stations at Bogalusa, Louisiana (tung nut); Holland, Virginia (peanuts); and Tifton, Georgia (peanuts). Contract research is also underway at Virginia Polytechnic Institute for study of equipment and methods for farm curing and drying of Virginia-type peanuts and at the Georgia Coastal Plain Experiment Station for determination of location, nature, and extent of losses and damage occurring in peanut harvesting and farm handling. Research on the processing of tung nuts is conducted at Bogalusa, Louisiana, in cooperation with the Mississippi Experiment Station and industry. Farm curing and drying of peanuts is cooperative with the Virginia and Georgia Experiment Stations.

Studies on effects of electric glow-discharge radiation on seeds and plant products have been continued at Knoxville, Tennessee, in cooperation with the Departments of Agricultural Engineering, Agronomy, and Nutrition of the Tennessee Agricultural Experiment Station and the Crops Research Division, ARS.

PROGRAM OF STATE EXPERIMENT STATIONS

Most of the State Agricultural Experiment Stations are engaged in some aspect of basic or applied research which is concerned with improving machines and methods for efficient harvesting and farm handling of the many economic crops which make up the total national agricultural production. Much of this research effort is cooperative with the Department.

Current research is concerned with the diverse problems involving a number of crops including peanuts, castor beans, and safflower.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Weed Control in Soybeans

Field studies were made in cooperation with the Missouri station to evaluate equipment for incorporating trifluralin (one pound per acre) and amiben (one and two pounds per acre) with the soil for weed control in soybeans.

Trifluralin performed best with a power rotary cultivator. Disk harrow plots had better weed control than check plots but not as good as power rotary cultivator plots. Laboratory studies were made to determine the distribution of trifluralin in the soil when incorporated with the power rotary cultivator and the disk harrow. Gas chromatographic analysis of soil samples showed that the power rotary cultivator concentrates the trifluralin in the upper inch of soil while the disk harrow concentrates the trifluralin at about two-thirds of its operating depth.

B. Oilseeds and Peanut Harvesting Equipment

1. Studies to determine the effect of pruning and training tung trees for mechanical harvesting showed that trees growing to a natural crown had significantly more growth than those trained to a 5-1/2 foot crown. In the pruning treatment, there was very little difference in the amount of growth put on by the different treatments. No fruit was produced in the training experiment in 1966 due to cold weather at blooming time.

2. Development of an experimental tung nut harvester has continued. Additional cleaning features have been added to improve the performance. Using the basic principles of this unit, thirteen harvesters were built commercially in 1966. All of these were used during the harvest season. These harvesters worked fairly well; however, they were too lightly constructed and trouble with conveying and cleaning mechanisms was experienced.

3. A study of peanut digger performance in Virginia showed that commercially available diggers left as much as 23% of the crop in the ground and an average of 25,000 pounds of soil per acre left mixed with the vine mass. An experimental digger equipped with either a standard conveyor and an elliptical wheel dirt-removing assembly or with two conveyors, left an average of 14% of the crop in the ground and an average of 14,000 pounds of soil per acre mixed with the vine mass.

Tests of the effect of inverting peanut windrows showed that peanuts from inverted windrows dried significantly faster than those from the random windrow which were in contact with the soil. Samples of these peanuts were taken over a 14-day period and analyzed for aflatoxin. No traces of aflatoxin were found.

4. Peanut harvesting loss and damage studies conducted in Virginia showed that the visible pod damage ranged from 14 to 37 percent. Total pod damage (both visible and invisible) ranged from 42 to 67 percent. Preliminary studies indicate that the combining damage can be reduced by operating the cylinders at slower speeds. Losses were also less at the slower cylinder speeds; however, all losses were rather low, ranging from 3.9 to 5.5 percent. Studies to determine the combine efficiency as affected by soil incorporated with the vines showed that neither pod damage nor recovery yield was affected by soil in the vine mass.

Investigations with an experimental recleaner to clean combine-run peanuts prior to drying showed that approximately 50% of the immatures could be removed from green combined peanuts which had 22% immatures. Following one- to seven-days exposure in the windrow before combining, the recleaner removed approximately two-thirds of the immatures which averaged about 17.5% of the total.

Investigations of the effect of type of windrow on drying rate and flavor of peanuts indicated that peanuts from inverted windrows, under Georgia conditions, dried only slightly faster during good drying weather. Under unfavorable drying conditions, the peanuts in the inverted windrow appeared to dry much faster than those in the normal or random windrow. A statistical analysis of the taste panel evaluations is not available, however, there do not appear to be any striking differences either as to type of windrow or exposure time in the windrow. Studies on peanut kernel temperatures reached within the windrow showed that all peanuts, regardless of position, may reach temperatures far above those recommended for drying with heated air. The highest temperatures were found to be in peanuts which were both in contact with the soil and exposed to the sun. These temperatures, measured in excess of 120° F., were approximately the same as those of the soil surface and of a black glove six inches above the ground. Studies also failed to detect the development of aflatoxin in the windrow in either random windrows or inverted windrows for this season. These studies included Spanish, Runner, and Virginia types which were left in the windrow either 0, 3, or 7 days. In none of these treatments was aflatoxin found in peanuts taken from the combine. The effect of clipping peanut vines, prior to digging, on drying rate indicated that there was no advantage in this operation. Approximately one-half of the top was clipped immediately prior to digging. When the peanuts were windrowed in the normal, random windrow or in an inverted windrow, the drying rate was about the same for these as for those from which the tops were not clipped. Studies to determine the effect of windrow type and exposure time on broken and damaged pods indicated that the percentage of peanuts coming from the combine is about the same regardless of these factors. The percent of damaged hulls prior to combining increased with exposure time; however, the peanuts which were in the windrow longer were less damaged by the combining operation. As a result, the total damage was about the same.

5. Under research contract at the Georgia Agricultural Experiment Station at Tifton, studies to determine the nature and extent of losses during the harvesting operations showed that, for this year, total losses were very low. The Virginia type had a higher percentage loss for both digging and combining. The combining losses were higher than the digging losses for the Spanish type. The two types of losses were about the same for the Runners, whereas most of the total losses for the Virginia type occurred in the digging operation. Studies to determine the effect of clipping peanut tops on pod losses indicate that the percentage of vine growth removed had little effect on recovery yield. In all instances at least

two inches of vertical growth was left. A sharp, sickle-type mower was used for these studies. The amount of forage (dry matter) recovered per acre ranged from 700 pounds per acre for the Spanish to 1,400 pounds per acre for the Virginia type. Average protein content of the forage was 12.4 percent, 12.8 percent, and 14.8 percent for the Spanish, Virginia, and Runner types, respectively. Tests to determine the nature and extent of digging losses showed that these losses did not increase appreciably up to the normal maturity date. Radioactive phosphorous was applied to the plants prior to digging and those recovered from the soil were put on x-ray film to determine whether the peanuts were actually connected at the time the phosphorous was applied. The analysis of this data has not been completed. Studies to determine the location within the combine at which the most damage occurs indicate that the first two picking cylinders contribute wery heavily to the damage. Peanuts were collected from the windrow and nine locations in the combine. Peanuts collected after the first three picking cylinders generally had a majority of the total damage. Indications are that the point at which the most damage occurs is influenced by the moisture content of the peanuts. As the moisture content decreases, less damage appears to occur at these cylinders and more appears to be contributed by the remaining components, with no appreciable difference in the total damage.

C. Tung Nut Processing

Preliminary tests on-the-farm drying of tung nuts were conducted using whole fruit. These tests indicated that the moisture content of 5 tons of fruit could be reduced from 41% to 13% in ten hours of continuous drying. Additional studies to determine proper air velocities, temperature, and drying time will be made.

D. Peanut Curing

1. Studies of the effect of different drying rates on aflatoxin development in peanuts under Virginia conditions showed no aflatoxin development in artificially cured peanuts. The time lapse between digging and the completion of drying ranged from 10 hours to 10 days. One sample of peanuts cured on a stack pole showed 4 p.p.b. of aflatoxin B_1.

Investigations to relate the curing time-temperature-moisture content to peanut quality factors indicate that short cycles of heated air and cooling air can increase the drying rate without decreasing peanut quality. Empirical equations are being developed to express this relationship.

2. Investigations were conducted to determine the development of aflatoxin in peanuts held between combining and drying under Georgia conditions. The three major types of peanuts were held for 24, 48, or 72 hours between combining and placing on the drier. These peanuts were aerated at 0, 0.1, 1.0, and 10 c.f.m. per cubic foot. No aflatoxin developed

in those peanuts combined immediately behind the digger or those exposed for three days in the windrow. In those which were dried to 10-15 percent moisture content and then rained on, traces of aflatoxin were found following these holding treatments. Its development appeared to be unaffected either by aeration rate or holding time. Similar peanuts which were placed directly on the drier did not show any aflatoxin development.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Oilseeds and Peanuts Harvesting Equipment

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II. NUTRITION, CONSUMER AND INDUSTRIAL USE RESEARCH

NUTRITION AND CONSUMER USE RESEARCH
Consumer and Food Economics Research Division, ARS
Human Nutrition Research Division, ARS

Problem. The assortment and characteristics of food available to consumers change constantly with the adoption of new practices of production, processing, and marketing. Changing constantly also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help meet the Department's responsibility to advise consumers on the quantity and variety of foods that will assure maximum benefit and satisfaction, research must continue on the nutritional requirements of persons of all age groups, on the nutrient and other values of foods, and on ways to conserve or enhance these values in household and institutional preparation and processing.

The kinds and amounts of foods consumed by different individuals and population groups must be determined periodically so that the nutritional adequacy of diets can be evaluated. Information on food consumption and dietary levels provides the guidelines needed for effective consumer nutrition programs. This information also furnishes the basis for market analyses for different commodities and for development and evaluation of agricultural policies and programs that relate to production, distribution, and consumer use of food.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of improved procedures for household food preparation, care and preservation; (3) nutritional appraisal of food supplies and diets of different population groups; and (4) development of guidance materials for nutrition programs.

The research is carried out by two divisions of the Agricultural Research Service -- the Human Nutrition Research Division at Beltsville, Maryland and the Consumer and Food Economics Research Division at Hyattsville and Beltsville, Maryland and Knoxville, Tennessee. Some of the research in both divisions is done under cooperative, contract or grant arrangements with State Experiment Stations, universities, medical schools, hospitals, research institutes, and industry. The total Federal scientific effort devoted to research in these areas is 81.7 man-years. It is estimated that 2.3 scientific man-years is concerned with studies related to oilseeds and peanut products.

Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and microorganisms concerned with defining human

requirements for nutrients and foods are not reported on a commodity basis, though some of the work is applicable to this report. This basic nutrition research represents a total Federal effort of 19.8 scientific man-years and is described in detail in the report of the Human Nutrition Research Division. Certain aspects of this research related to fats and oils are considered briefly in this report.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Quality and Use of Oilseed and Peanut Flours

Research in cooperation with the Agency for International Development, State Department, and other ARS Divisions, was continued on improving the eating quality of foods supplemented with cottonseed, peanut, and soy flours. These foods of plant origin are designed to meet the protein needs of the peoples of developing countries.

Full-fat soy flour samples prepared by the extruder process and a simple process developed for village use were investigated to determine the functional properties and quality when tested in a beverage and baking powder biscuits. Soy flour from the extruder process produced the most satisfactory beverage; soy flour from the village process had poor dispersing properties. There was little difference between samples when soy flour replaced 8 percent of the wheat flour in baking powder biscuits.

Seven experimental flours made from glanded or glandless cottonseed were received from the Southern Utilization Research and Development Division. Gossypol had been removed from the glanded cottonseed by either acetone or hexane extraction. Beverages, biscuits, and breads containing 1 to 10 percent cottonseed flour, based on the weight of finished product, were evaluated by a panel for appearance, aroma, texture, color, flavor, and general acceptability. Products containing acetone extracted, glanded cottonseed flour were generally poor in color and flavor. Better results were obtained with hexane-extracted cottonseed flour. Improved processing techniques are necessary to improve the characteristics of these cottonseed flours. Glandless cottonseed flours produce products of acceptable flavor. Glandless cottonseed is not a commercially available commodity at this time but shows potential for future international use.

Food formulas that include peanut or soy flour as a major ingredient and developed at Beltsville were further tested under a cooperative agreement with Howard University at Washington, D.C. The formulas were tested for ease of preparation and acceptance by students from developing countries. These formulas will serve as guidelines for household and institutional use of plant proteins in developing countries and should be helpful to extension and Peace Corps workers, nutritionists, and staff in child feeding centers in these countries. Two publications of basic formulas for soups, breads, main dishes, beverages, desserts, and cereal products, such as porridges using peanut and soy flour, have been completed. Twenty-five peanut and 28 soy formulas are in

family-size portions. Community-size (50 portions) formulas include 28 peanut and 31 soy formulas. Instructions for preparing 50-portion amounts specified the yield, portion size, grams of protein, and the number of calories per portion. The formulas also are shown in the metric system.

B. Nutritional Evaluation of Fats and Oils

1. Heated and oxidized fats. Research to determine the effect on physiological response of aerating fats and oils at 140° F. for 40 hours has been completed under a research contract with Columbia University at New York City. The fats constituted 20 percent of each diet with all other dietary ingredients remaining constant. In addition to the results previously reported (see 1966 report, p. 121), evidence was obtained to suggest that certain fats and oils contain substances that aggravate the development of enlarged thyroids in rats when diets contain marginal amounts of iodine. Olive oil produced a high incidence of thyroids weighing more than 100 mg., in comparison with normal thyroids of 23-31 mg. When the diet contained butter, lard, or beef tallow, the incidence of large thyroids was low. Chicken fat, soybean oil, and corn oil were intermediate in their effect on thyroid size. Thyroid size was not influenced by mild oxidation of the fat consumed.

Long-term feeding studies of diets containing fresh cottonseed oil, corn oil, lard, or hydrogenated vegetable oil or these same oils heated for 120 hours at 360° F. have been completed under contract with Swift and Company at Chicago, Illinois. Tissue masses from the animals fed these diets were evaluated microscopically at Beltsville. Mammary tumors occurred in approximately 50 percent of the female rats, an incidence similar to that reported by others for the aging rat. Their presence appeared to be unrelated to the source of the fat fed and no differences between fresh and heated fat were observed. The incidence of non-mammary tumors was relatively low, amounting to 15 percent, too few to establish any significant dietary differences. A paper reporting these findings has been prepared for publication.

2. Insecticides and dietary fats. Research has continued under contract with Swift and Company at Chicago, Illinois, to determine reproductive performance of rats fed diets which include different kinds of fats with and without a mixture of chlorinated hydrocarbons, fat soluble insecticides. Fats commonly used in food preparation were fed and include lard, cottonseed and soybean oil, and a hydrogenated vegetable fat. The level of the insecticides fed did not exceed currently accepted tolerance levels. The results already obtained with the parent and first generation indicate the importance of investigations to determine possible carry-over effects of diet to succeeding generations. Final evaluation has not been completed but there appear to be substantial differences in response to the various fats; in addition, the response to the insecticides may differ with the kind of fat fed and with the number of generations that have received the diet containing the insecticide.

C. Tables of Food Composition

1. B-vitamins in foods. Summarization of data and derivation of representative values for a publication on the content of pantothenic acid, vitamin B_6 and vitamin B_{12} are now complete for some 700 items of food. The values will provide the basis for evaluating food supplies and diets with respect to these vitamins.

2. Nutritive value of retail and household units of food. The development for publication of a table showing nutritive values of foods in terms of common retail and household units is continuing. Values will be given for proximate composition, calcium, phosphorus, iron, sodium, potassium, vitamin A, thiamine, riboflavin, niacin, ascorbic acid, and selected fatty acids. Final values are now ready for more than 500 items of food and are nearing completion for many others.

D. Food Consumption and Diet Appraisal

1. 1965 nationwide survey. Analysis of the household data showed that families surveyed in the spring of 1965 spent 36 cents of their food dollar for meat, poultry, fish and eggs; 19 cents for vegetables and fruits, including juices; 13 cents for milk and milk products; 12 cents for flour, cereals, and bakery products; 10 cents for beverages other than milk and juice; and 10 cents for fats, sweets and all other foods. This division of the food dollar varied little among groups of families whether classified by region, urbanization or income. Choices within these broad groups did vary. For example, farm families used more flour, fat, sugar, and eggs per person and less bakery products than city families. Southern families used the most pork, poultry, and fish and the least beef; western families used the most beef.

Families surveyed in the spring of 1965 used more beef and poultry and less pork, fish and eggs than families surveyed in the spring of 1955. The families surveyed in 1965 also used more frozen milk desserts, cheese, dry and fresh skim milk and less fresh whole milk, cream, and evaporated milk; more canned and frozen vegetables and fruits and less fresh vegetables and fruits; more breakfast cereals and bakery products other than bread and less flour, bread and cereals other than breakfast cereals; more margarine and oils and less butter and shortening. Many of the changes reflected the trend to increased use of commercially-prepared foods. There was also greater use in 1965 of foods associated with snacking--ades and punches, soft drinks, potato chips, luncheon meat, peanut butter, crackers, cookies, doughnuts and candy.

Papers reporting findings on the food consumption of households in spring 1965 were presented during the reporting period at three National meetings. One preliminary report was published and a second was prepared for publication. Final reports are in preparation--one for the U.S. as a whole and one for each of the four census regions. These reports will provide information on the percentage of families using major groups, subgroups, and selected items of foods as well as the quantities and money value of the foods consumed. This information will be given separately for urban, rural nonfarm, and rural farm

families and for all urbanizations combined. Another classification will be by income of family.

2. 1967 survey in two counties in Mississippi. In May 1967, a survey was made to evaluate two types of food distribution programs in two counties in the Mississippi Delta. The survey was made by the Consumer and Food Economics Research Division, ARS, in cooperation with the Economic Research Service. In Washington County, a Food Stamp Program had replaced a Food Donation Program in March 1967. In Sunflower County, a Food Donation Program of long standing was in operation. The families surveyed included participants and eligible nonparticipants in both the Food Stamp Program and the Food Donation Program.

Preliminary evaluation of the data indicated that the average diet was poor. Foods most needed to improve the diets of these families are milk products, vegetables and fruits. Diets of families who participated in the food program were similar in many respects to those who were eligible but did not participate.

Money value of the food used averaged about $4.00 a person a week (including value of free food stamps and donated commodities). This is about 25 percent less than the cost of the USDA Low-cost Food Plan for the South. On the average the families included in the survey spend about one-half of their incomes on food.

Data on height and weight were obtained as an indication of the growth and nutritional status of children 2 to 12 years old in the families surveyed and were evaluated by the Human Nutrition Research Division. Children in families that were participating in a food program were no different in height and weight for age than children in nonparticipating families. In height, 36 percent of the children were above average for their age, 22 percent were average, and 42 percent were below average for their age when compared with reference standards for U.S. children. In weight, 44 percent of the children were above average for their age, 30 percent were average, and 26 percent were below average. When weight was related to height, 44 percent of the children were above average weight for their height, 36 percent were average weight for height, and 20 percent were below average weight for height.

3. Preschool children in Hawaii. Data needed to assess the nutritional situation of children 2 to 3 years of age in low-income families and middle-income families in Honolulu have been collected. Included are a 3-day record of the child's food intake, a physical examination record, and information on the child's early diet, on the mother's food practices and attitudes, and on the family's socioeconomic situation. Data collected in biochemical, clinical, and psychomotor tests are being evaluated. The research is being carried out by the University of Hawaii under cooperative agreement with the Consumer and Food Economics and the Human Nutrition Research Divisions.

4. Nutritive value of the national food supply. Food energy (calories) and selected nutrients provided by the per capita food supply are estimated each year by the Consumer and Food Economics Research Division from data on apparent civilian consumption, retail basis, developed by the Economic Research Service. The estimates show that shifts in food consumption over the years have resulted in changes in the sources of fat, carbohydrate and protein. Vegetable fat now accounts for a higher percentage of total fat because of the shift from butter to margarine and from lard to shortening and the sharp increase in use of salad and cooking oils. The share of calories derived from total nutrient fat which increased from 1909 to the early 50's has changed little since. Saturated fatty acids account for a smaller share of the total fat today than they did 55 years ago--37 percent compared with 40 percent--even though the American diet now contains more fat. Oleic acid continues to account for about 41 percent of the total fat. The share attributed to linoleic acid has been increasing and is now roughly 13 percent. Starch and sugars now contribute about equally to total carbohydrates; in 1909-13, two-thirds was provided by starch and one-third by sugars. Animal products contribute two-thirds of the protein today compared to one-half 55 years ago.

5. Nutrient content of Type A school lunch. A nationwide study of the nutrient content of Type A lunches served to 6th graders is being carried out by the Consumer and Food Economics Research Division in cooperation with the School Lunch Division, Consumer and Marketing Service. The study was undertaken to obtain data needed for evaluating the Type A pattern. Twenty lunch composites from each of 300 schools in 19 states in 5 geographic regions have been analyzed by a contractor, the Wisconsin Research Alumni Foundation, for proximate composition, fatty acids, and 12 minerals. Analyses are in progress for seven vitamins, iron and residues of chlorinated hydrocarbon insecticides.

In general, the lunches met the nutritional goal of one-third of the 1963 NRC Recommended Daily Dietary Allowance for 9 to 12 year olds for energy, calcium and protein. The average energy level of the lunches from the 300 schools was 735 Calories--the goal for girls and a little under the goal of 800 Calories for boys. On the average, 39 percent of the calories were provided by fat in the lunches. The average calcium content was 400 milligrams per lunch--a little more than the goal of 367 milligrams. For protein, all lunches met the goal of one-third of the Recommended Daily Allowance for 9 to 12 year olds--18.3 grams for girls and 20 grams for boys.

6. Acceptance of Type A lunches. A study of factors affecting acceptance of the lunch program by 10th grade students in Louisiana is being carried out under cooperative agreement with Louisiana State University. Thirty students from each of 17 schools, their parents and the officials of the schools provided information for the study. Included were urban and rural schools, large and small schools, and schools with low, medium and high levels of participation in the lunch program.

Foods most frequently reported as liked by students were main dishes, sandwiches, potatoes, rolls, desserts and milk. Foods most frequently disliked were vegetables and salads. According to reports of reactions to nine foods, the taste of a food was the most important element in determining whether it was liked or disliked.

E. Support for Food and Nutrition Programs

1. The fifth national Nutrition Education Conference was held in Washington, D.C., February 20-22, 1967, with about 275 persons representing a wide variety of agencies and disciplines from most of the states. The theme was "effective communication" and coordination of nutrition programs as a means of facilitating behavioral changes in eating habits. The Conference was cosponsored by the Consumer and Food Economics Research Division and the Interagency Committee on Nutrition Education.

2. Bimonthly publication of Nutrition Program News, which reaches some 7,000 workers in nutrition and related fields was continued.

3. Technical assistance to programs. Nutrition research findings continue to be studied and interpreted for application to problems in food selection and food use. Technical assistance was given by nutritionists to programs of other government agencies such as the food and nutrition programs of Project Head Start, Office of Economic Opportunity. Talks to groups involved in community nutrition programs, radio and TV tapes on nutrition, and consultant help and participation in conferences contributed to coordination and strengthening of nutrition programs.

4. Food for low-income families. Recipes developed for peanut butter, raisins, and rolled oats were prepared by Human Nutrition Research Division for distribution to low-income families participating in the USDA food distribution program or the Food Stamp Program. These supplement the series of 17 leaflets on a variety of commodities prepared earlier and now available for national distribution as part of the Department's participation in the Federal program to combat poverty. This work, in cooperation with the Consumer and Marketing Service, will be continued. Negotiations were completed with the University of Maryland to have USDA recipes tried and evaluated by low-income families living in housing developments in Washington, D.C.

5. National school lunch program. Research on large quantity food preparation and food quality in the Human Nutrition Research Division has provided help to school lunch managers across the nation to make the best use of donated food commodities available to them and other foods obtained on the local market. "Favorite" recipes from schools were standardized and published for other schools to try. A survey of pupil acceptance of these recipes in about 100 schools in five areas of the United States is in progress. Food uses for peanut butter and raisins were developed to help schools use the large quantities distributed to them.

6. Project Head Start--food buying guide and recipes. A 130-page manual prepared by the Human Nutrition Research Division for the Head Start Program of the Office of Economic Opportunity gives quantity recipes and food buying guides needed to prepare nutritionally adequate meals for groups of 25, 50, or more preschool children from low-income families. Food served in Head Start Centers must be inexpensive to buy, easy to prepare with limited kitchen equipment, and attractive and appealing to small children.

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

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FLAX UTILIZATION - INDUSTRIAL PRODUCTS
Northern Utilization Research and Development Division, ARS

Problem. Traditional markets for linseed oil, the major drying oil produced and used in the United States, are threatened by widespread use of synthetic products derived from nonagricultural sources. In recent years, annual domestic use of linseed oil has ranged from 363 to 394 million pounds in contrast to the postwar high of over 700 million pounds in the early 1950's. This decrease was caused primarily by displacement by synthetic materials capable of better performance, particularly in protective coatings.

To restore the level of use of linseed oil, new or expanded markets are urgently needed. Such markets can be achieved by an adequate program of basic and applied research. Recent studies by Department scientists have resulted in commercial manufacture and sale of linseed emulsion paints for exterior use that are competitive with synthetic resin emulsion paints. Other new products from linseed oil to which Department research is contributing are protective coatings for use in curing fresh concrete and in preventing its deterioration from de-icers and freezing and thawing in winter. These new uses have improved the competitive position of linseed oil in relation to synthetics, but additional research is needed to insure maximum acceptance and consumption of linseed oil in these new markets and to provide still other new or improved products that can maintain and increase its use in all types of protective coatings.

Other new outlets can be realized by chemical modification of linseed oil to obtain materials that will find applications in the multibillion-pound annual market for products of the organic chemical industry. To furnish a sound basis for chemical modification, a broad program of basic research on linseed oil is required to furnish new leads and new concepts that will point the way to those products having the best chance for acceptance.

USDA AND COOPERATIVE PROGRAMS

The Department conducts a continuing, long-range program involving analytical, organic, and physical chemists and chemical engineers engaged in basic research on the chemical reactions of linseed oil and its component fatty acids and in the application of the knowledge gained to the development of new or improved products for the chemical and protective coating industries.

The Federal scientific effort concerned with research on industrial uses for linseed oil totals 14.2 scientist man-years. Of this number, .7 is devoted to chemical composition, physical properties and structure; 11.7 to chemical and physical investigations to improve products; .7 to microbiology and fermentation; and 1.1 to technology--process and product development.

Research at Peoria, Illinois, on chemical composition, physical properties and structure (.7 scientist man-year) involves study of mass spectroscopy for elucidating the chemical and molecular structure of glyceride oils and their derivatives.

Research at Peoria, Illinois, on chemical and physical investigations to improve products (10.8 scientist man-years) emphasizes basic studies on the chemistry of linseed oil and linseed fatty acids with the objective of discovering new reactions and derivatives having potential applications in the chemical and protective coatings industries. The work also includes basic investigations of problems related to development of emulsion paints and coatings from linseed oil and to durability of linseed oil films.

Contract research (.3 scientist man-year) involves the Northern Division's share in support of a cooperative agreement among the Division, North Dakota State University, and the National Flaxseed Processors Association. Research under this agreement is conducted at North Dakota State University and involves preparation and evaluation of linseed oil derivatives for use in improving durability of protective coatings. During the year, contract studies were completed by Stanford Research Institute, Menlo Park, California, on properties and reactions of new vinyl copolymers of linseed oil, and by North Dakota State University of Agriculture and Applied Science, Fargo, North Dakota, on aldehyde oils as components of protective coatings. A grant (.6 scientist man-year) has been made to the University of Illinois at Chicago Circle, Chicago, Illinois, for studies of photochemistry of linseed oil polymers on metal oxide substrates.

Research at Peoria, Illinois, on microbiology and fermentation (.7 scientist man-year) is concerned with exploration of the possibilities of preparing new and useful derivatives by fermentative modification of fatty acids.

Research on technology--process and product development involves research contracts (1.1 scientist man-years*) with Kansas State University, Manhattan, Kansas, for studies on the use of linseed oil as a single coating for both curing and protection of concrete; and with Fabric Research Laboratories, Dedham, Massachusetts, for investigations on poly(ester-acetals) and poly(amide-acetals) derived from aldehyde oils. During the year, Archer Daniels Midland Company, Minneapolis, Minnesota, completed contract research involving pilot preparation of various aldehyde oil products needed for developmental investigations.

The Department also sponsors research in this area under grants of PL 480 funds to foreign institutions. Chemical and physical investigations to improve products are conducted under a grant to the Regional Research

*Work covers more than one commodity; only effort allocated to flax is included in total.

Laboratory, Hyderabad, India, for exploratory research on hydroxylation reactions of linseed and safflower oils (5 years, 1963-1968). During the year, research* was completed on studies on stereospecific polymerization of polyunsaturated fatty esters at the Experiment Station for the Fats and Oils Industry, Milan, Italy.

Research on microbiology and fermentation involves a grant to the University of Baroda, Baroda, India, for studies* on production of microbial lipases useful for modifying vegetable oils (5 years, 1965-1970).

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 1.5 scientist man-years is devoted to research on other oilseed crops, including flax.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition, Physical Properties and Structure

1. Mass spectroscopy. Mass spectroscopic investigations of chemical and molecular structure of glyceride oils and their derivatives are relevant to industrial utilization of linseed oil. Results are reported under "Soybean Utilization - Food," subheading A-1.

B. Chemical and Physical Investigations to Improve Products

1. Cyclic fatty acids. Tetrafluoroethylene was successfully reacted with conjugated linseed oil to form adduct in 70-percent yield (based on conjugation). This product will be evaluated in drying oil formulations. Adducts of even-numbered α-olefins (C_6-C_{20}) and methyl octadecadienoate were purified by crystallization and hydrogenated. Products are being characterized. Alkyd resins can be prepared from tetrafluoroethylene adduct of conjugated linoleic acids or conjugated linseed fatty acids that are compatible with selected commercial alkyds. These products are being evaluated as vehicles for paints. Synthesis, purification, and analysis of the glycol formed in the oxidation of the ethylene adduct of conjugated linoleic acid have been satisfactorily accomplished. Diesters of C_{18} saturated cyclic acids from linseed oil have previously shown large (375%) increases in viscosity when subjected to the 400° F. oxidative stability test in the presence of copper. By use of a new inhibitor system, viscosity increase has been reduced to 17 percent.

2. New polymers and derivatives for use in water-soluble and other coatings. Polymers prepared from N,N,bis(2-hydroxyethyl)linseed amide (HELA) dibasic acids and toluene diisocyanate (TDI) and containing ester,

*Effort prorated between linseed and soybean oils.

amide, and/or urethane linkages gave films with a range of hardness values, varied alkali resistance and drying characteristics depending on the polymer composition. Films of polyesteramides of isophthalic acid modified with TDI and baked at 150° and 200° C. for 10-30 minutes reached maximum hardness 1 week after baking, except film baked at 200° C. for 30 minutes which did not increase in hardness. Air-dried films from this polymer achieved equivalent hardness in 1 week. Increasing the amount of HELA in isophthalic polyesteramides resulted in a decrease in molecular weight of polymer and slower drying and softer films. TDI modified polyesteramides (10% excess HELA) from endic anhydride and hydrogenated endic anhydride gave faster air drying and harder films than other polymers of this type prepared to date. New dibasic acids in which the fatty chains are bridged together through 1,2-ethanedithio or 1,6-hexanedithio groups were synthesized from methyl oleate. Films from an H_2S-linseed oil reaction product were hard and alkali resistant when baked 1 hour at 250° C. under CO_2. Copolymers of vinyl tetrahydroxystearate or its di-dioxolane derivative with vinyl chloride gave flexible films.

3. Linseed oil films and emulsions. Tensile properties of unsupported pigmented and unpigmented linseed oil films showed that the unpigmented were much weaker and elongated more than films containing TiO_2 or SnO_2. When water-soaked, the pigmented films retained about two-thirds of their breaking strength at 50 percent R.H. Zinc oxide gave stronger but less extensible films than did the other pigments. When water-soaked, films containing ZnO retained only about one-fifth of the 50 percent R.H. breaking strength. Unpigmented films and those containing TiO_2 and SnO_2 showed little or no swelling when soaked in water, whereas those containing ZnO swelled 19 percent. As little as 1 percent ZnO by volume, either alone or in combination with TiO_2, can be responsible for the undesirable tensile and swelling properties of linseed oil films. There appears to be little difference between M-37 and S-70 linseed oil in this respect. Treatment of ZnO with either organic or inorganic phosphate alters surface properties of this material. Inorganic phosphate causes ZnO to become more water wettable, and organic phosphate treatment results in a more oil wettable pigment. Zinc oxides with either treatment cause less swelling of linseed oil films than do untreated pigments.

Paint formulations were developed that permit the use of cationic emulsifiers in preparing emulsion paints from any paint-grade linseed oil. The paints showed good shelf stability and had good film properties. During the study, it was found that a cationic emulsion paint formulation successful for nonbodied oils was inadequate when bodied oils were used. Changes in emulsifier composition, such as combinations of nonionic and cationic surfactants, resulted in acceptable paint systems from bodied oils. These paints dried rapidly and films prepared on glass were rather insensitive to attack by water. Viscosity-stable cationic emulsion paints were made with only about 1 percent total concentration of emulsifiers and dispersing agents. Films from these paints dry rapidly. A method is suggested for

coating pigments with linseed oil that involves spray drying a slurry of pigment and a solution of linseed oil in organic solvent. The oil-coated pigments can be dispersed in water, but a completely satisfactory surfactant system has not yet been found.

In studies conducted under a cooperative agreement among the Northern Division, the North Dakota State University, and the National Flaxseed Processors Association, preliminary screening revealed that reaction products of linseed oil and mercuric acetate show promise as agents to combat growth of mildew in linseed oil paints. These mercury derivatives are fairly stable to boiling water, copper plate, light, and ultraviolet exposure.

4. Glyceride polymers. Work on the preparation and polymerization of fatty esters and their derivatives was continued under a PL 480 grant to the Experiment Station for the Fats and Oils Industry, Milan, Italy. Conjugated linolenyl alcohol (t,t,t) and the corresponding bromide were prepared. The latter product was reacted with $TiCl_4$-Et_3Al in hexane for 24 hours but no polymerization occurred. Conjugated isomerized isopropyl linolenate was polymerized with $TiCl_4$-Et_3Al (ratios of 1:1, 1:2, 2:1) at 100° C. for 24 hours. A polymer was produced that showed no evidence of conjugated trans bonds (IR at 10.14 μ). The structure of this product is being studied. Polymerization studies on conjugated isopropyl linoleate and conjugated benzyl linoleate under the conditions described for isopropyl linolenate gave no polymer. Polymerization experiments with conjugated isomerized ethyl linolenyl ether under conditions described for isopropyl linolenate gave a small amount of a solid polymer.

5. Hydroxylation of linseed oil. Five routes are being examined for introduction of monohydroxy functions into safflower and linseed oils--epoxidation, sulfation, autoxidation, bromination and selenation. Presence of a complexing agent during catalytic hydrogenation of a fatty epoxide was found to be an excellent means of preserving residual unsaturation. Cupric nitrate performed as well as silver nitrate as the complexing agent, but palladium, zinc and cuprous chlorides were not effective. By this method hydroxy products can be obtained from unsaturated oils with a gain of 2.1 units of hydroxyl value (HV) per unit of iodine value (IV) lost. Work on the epoxidation route is complete. Sulfation of oleic-rich oils, followed by hydrolysis, yielded products having HV and IV ranging approximately from 50-60. Linoleic-rich oils could not be converted to hydroxy glycerides by this method because excessive side reactions occurred with ease. Autoxidation of safflower oil to a peroxide value of 2,225 and reduction of hydroperoxide gave a conjugated (20%) oil having HV of 80 and an IV of 122. Attempts to achieve initially greater peroxide values were not successful. Use of silver salts for replacement of bromine by hydroxyl in safflower oil brominated with N-bromosuccinimide gave incomplete reaction, product typically showing about 3 percent residual Br and HV 100. Oxidation of methyl oleate with SeO_2 (0.5 mole) gave a product having IV 67 and HV 105.

6. Aldehyde oils and derivatives. Research on preparation of aldehyde oils and derivatives is relevant to industrial utilization of linseed oil. Results are reported under "Soybean Utilization - Industrial Products," subheading B-1.

C. Microbiology and Fermentation

1. Microbial modification of fatty acids. Research to explore possibilities of microbial modification of fatty acids as a means for preparing new and useful derivatives is pertinent to industrial utilization of linseed oil. Results are reported under "Soybean Utilization - Industrial Products," subheading C-1.

D. Technology--Process and Product Development

1. Linseed oil coatings for concrete. Contract research at Kansas State University indicated that although continued difficulty is being encountered in finding meaningful laboratory tests for screening and evaluation of linseed oil coatings for protecting and curing concrete, field tests uniformly reveal superior properties of such coatings. Early field results were so promising that the NU-developed boiled oil emulsion is now being manufactured commercially. Skid-resistance tests of highways coated with linseed antispalling compound showed that dry skid resistance recovered to a value equal to or exceeding that of uncoated concrete within 3 hours after coating. Wet skid resistance also recovered rapidly, but not as fast as the dry. Freeze-thaw durability tests of concrete beams cured with NU boiled linseed oil emulsion show that at 100 cycles the treatment inhibits freeze-thaw deterioration. Freeze-thaw evaluation of concrete made with linseed-oil-treated Florence limestone (coarse aggregate) indicates that concrete made with treated aggregate was much less deteriorated at 20 cycles than the control concrete. However, at 65 cycles all specimens were almost completely deteriorated.

2. Aldehyde oils and derivatives. Engineering studies on preparation of aldehyde oils and derivatives is relevant to industrial utilization of linseed oil. Results are reported under "Soybean Utilization - Industrial Products," subheading D-1.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Chemical and Physical Investigations to Improve Products

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Technology--Process and Product Development

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*Research supported by PL 480 funds.

SOYBEAN UTILIZATION - INDUSTRIAL PRODUCTS
Northern Utilization Research and Development Division, ARS

Problem. As an industrial oil, soybean oil is faced with growing competition from synthetic products derived from nonagricultural sources. As an industrial source of linoleic acid, soybean fatty acids must also compete with tall oil fatty acids, a byproduct of paper manufacture. Largely because of effective research, nonfood usage of soybean oil has rather consistently accounted for about 10 percent of domestic disappearance. The best opportunity for maintaining or increasing industrial applications of soybean oil is to be found in development of nontraditional products that can compete with synthetics in the multibillion-pound market for resins, fibers, coatings, plastics, plasticizers, pesticides, and paper and textile chemicals. To achieve the objective, more fundamental information is needed on reactions of soybean oil, especially those that will preserve the glyceride structure, and on the physical and chemical properties of the products.

USDA AND COOPERATIVE PROGRAMS

The Department has a continuing, long-range program involving analytical, organic, and physical chemists, and chemical engineers engaged in basic and applied research to obtain new information on chemical reactions of soybean oil and its components and to use this information to develop new or improved products for use by the chemical and other industries. In addition, microbiologists are engaged in a limited study of the possibilities of fermentative modification of fatty acids derived from soybean oil.

The Federal scientific effort for research on industrial utilization of soybean oil totals 11.1 scientist man-years. Of this number, .8 is devoted to chemical composition, physical properties and structure; 7.6 to chemical and physical investigations to improve products; 1.7 to microbiology and fermentation; and 1.0 to technology--process and product development.

Research at Peoria, Illinois, on chemical composition, physical properties and structure (.8 scientist man-year) is devoted to mass spectrometric investigations of chemical and molecular structure of glyceride oils and their derivatives.

Research on chemical and physical investigations to improve products in progress at Peoria, Illinois (7.2 scientist man-years), emphasizes studies of aldehyde derivatives of soybean oil. A research contract with the University of Illinois, Urbana, Illinois, provides for basic studies on the mechanism of homogeneous hydrogenation with organometallic catalysts. A portion of this effort is allocated to industrial utilization of soybean oil (.4 scientist man-year). A research contract with North Dakota State

University of Agriculture and Applied Science, Fargo, North Dakota, for investigations of aldehyde oils as components of protective coatings was completed.

Research at Peoria, Illinois, on microbiology and fermentation (1.7 scientist man-years) involves exploration of possibilities for producing industrially useful derivatives by microbial conversion of fatty acids.

Research on technology--process and product development involves a research contract (1.0 scientist man-year*) in effect with Fabric Research Laboratories, Dedham, Massachusetts, for investigations on poly(ester-acetals) and poly(amide-acetals) derived from aldehyde oils. During the reporting period, the Archer Daniels Midland Company, Minneapolis, Minnesota, completed contract research involving pilot preparation of various aldehyde oil products needed for developmental investigations.

The Department also sponsors research in this area under grants of PL 480 funds to foreign institutions. Under the heading chemical and physical investigations to improve products, research** was completed under a grant to the Experiment Station for the Fats and Oils Industry, Milan, Italy, for studies on stereospecific polymerization of polyunsaturated fatty esters.

Research on microbiology and toxicology involves a grant to the University of Baroda, Baroda, India, for studies** on production of microbial lipases useful for modifying vegetable oils (5 years, 1965-1970).

PROGRAM OF STATE EXPERIMENT STATIONS

The State stations did not report research in this area.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition, Physical Properties and Structure

1. Mass spectroscopy. Mass spectrometric investigations of chemical and molecular structure of glyceride oils and their derivatives are relevant to industrial utilization of soybean oil. Results are reported under "Soybean Utilization - Food," subheading A-1.

B. Chemical and Physical Investigations to Improve Products

1. Aldehyde oil derivatives. A survey of possible alternative procedures for ozonolysis and decomposition of ozonolysis products revealed none giving

*Work covers more than one commodity; only effort allocated to soybeans is included in total.

**Effort prorated between linseed and soybeans.

higher carbonyl yields than the presently used procedure (ozonolysis in a reactive solvent followed by chemical or catalytic reduction). Ethyl and butyl azelaaldehydate were prepared in high purity by simplified procedures. These esters are more resistant than the methyl derivative to hydrolysis, ammonolysis and aminolysis. High yields of methyl 9-hydroxynonanoate (potential intermediate for polyesters) were obtained by catalytic hydrogenation of ozonolysis products of soybean methyl esters. 9-Aminononanoic acid (nylon-9 intermediate) was prepared in overall yields of more than 60 percent from soybean butyl esters via the azelaaldehydate route. Yields of high-purity amino acid as high as 94 percent were obtained by reductive alkylation of ammonia with methyl (MAZ) and ethyl azelaaldehydates followed by hydrolysis of the unisolated amino ester. The amino acid was polymerized by heating without catalyst to give a nylon-9 polymer. Poly(ester-acetals) and poly(amide-acetals) were successfully used as polar "liquid" phases for GLC columns thermally stable to 350° C. A group of poly(ester-acetals) prepared by bulk polymerization of MAZ glyceryl acetal (MAZGA) with a variety of catalysts have been characterized to elucidate their properties and potential as intermediates. A tough, elastic crosslinked polymer was obtained by heating an MAZGA poly(ester-acetal) with p-toluenesulfonic acid and zinc oxide.

2. Cyclic fatty acids. Studies on the preparation of cyclic fatty acids are relevant to industrial utilization of soybean oil. Results are reported under "Flax Utilization - Industrial Products," subheading B-1.

C. Microbiology and Fermentation

1. Microbial modification of fatty acids. The pseudomonad NRRL P-1151, now NRRL B-3266, oxidizes oleic acid to a mixture of 10-ketostearic and 10-hydroxystearic acids. Addition of minimal amounts of oleic acid during growth of the bacterium provides more rapid conversion of oleic acid to product. No enzyme activity was detected in the growth medium. Complete utilization of the substrate oleic acid appears to shift the ratio of products toward the keto acid, suggesting that the hydroxystearic acid is an intermediate. Fermentation under anaerobic conditions showed that 10-hydroxystearic acid is produced preferentially when oxygen is absent, whereas 10-ketostearic acid is major product when oxygen is present. Continued incubation after complete utilization of oleic acid results in degradation of the initial oxidation products by chain shortening. Two products arising from beta oxidation of 10-ketostearic and 10-ketopalmitic acid by B-3266 have been identified as 4-ketolauric and 6-ketolauric acid, respectively. Degradation of the 10-hydroxy fatty acids has been eliminated by use of anaerobic fermentation conditions. Oxygen-containing products are formed by fermentation of linoleic or linolenic acids with B-3266 under anaerobic conditions. Presumably, the products are the corresponding 10-hydroxy unsaturated acids.

Under a PL 480 grant at the University of Baroda, Baroda, India, several strongly lipolytic bacteria have been isolated from sewage. A strain of

Pseudomonas aeruginosa has been extensively investigated. This organism produces a lipase when grown on a medium of salts, vitamins, glycerol, casein hydrolyzate and yeast extract. The level of glycerol is critical and 0.2 percent is optimum. Likewise, 0.2 percent casein hydrolyzate is optimum. The best medium for lipase production differs from a medium for maximum growth, since growth is greater when larger amounts of glycerol and casein are used. The lipase was isolated from the organism in the form of acetone powders. The enzyme showed optimum activity at pH 7.0 when run at 25 to 28° C. Calcium ion was found to activate the enzyme. Ninety percent of a soybean oil substrate was hydrolyzed in 3 hours with the production of free fatty acids plus lesser amounts of mono and diglycerides.

D. Technology--Process and Product Development

1. Aldehyde oils and derivatives. In the fundamental investigation of the crosslinking reaction involving poly(ester-acetals) and poly(amide-acetals), evidence was obtained that the size of the acetal ring influenced the reactivity of the poly(ester-acetal) during the reaction. However, the effect of ring size was not as great as hoped. The use of a promoter such as 3,3-bis-(chloromethyl)oxetane in combination with certain metal catalysts permitted crosslinking to occur at relatively mild conditions of 150° C. and 1 to 3 hours. Copolymers with 50 percent of diglycerol acetal of methyl azelaaldehydate and nylon-6 pentaerythritol acetal copolymers are being prepared for testing as industrial products. These studies are being conducted under a contract with Fabric Research Laboratories.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Chemical and Physical Investigations to Improve Products

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SOYBEAN UTILIZATION - FOOD
Northern Utilization Research and Development Division, ARS

Problem. Worldwide shortages of dietary protein and of food fats pose a problem that urgently demands solution. Since soybeans can furnish both of these nutritionally essential substances, foreign markets provide a promising outlet for the rapidly increasing production of soybeans in the United States.

U. S. soybeans could play a dominant role in alleviating the protein shortage in developing countries and elsewhere around the world, if soybean meal, flour, protein, and protein concentrates can be successfully used in food products tailored to meet the various nutritional and palatability requirements. Achievement of the maximum share of foreign food markets will require intensive research to acquire more basic information on components that affect nutritional quality, flavor, and other important characteristics of soybean food products. In addition, better knowledge of the effects of processing on these components is needed.

Soybean oil, now the major edible oil of the United States, is the most important source of nutritionally important linoleic acid. However, this oil contains an unstable component (linolenic acid) that limits its use as a liquid oil. To increase opportunities for foreign utilization of soybean oil, more information is needed to show how to eliminate unstable linolenic acid without loss of nutritive value; to determine the extent to which minor constituents influence flavor and other properties of the oil; and to discover methods for modifying hydrogenated soybean oil to achieve desired functional properties such as melting point and texture. A broad program of basic and applied research is required to achieve the objective.

USDA AND COOPERATIVE PROGRAMS

The Department has a continuing, long-range program involving analytical, organic, and physical chemists, biochemists, and chemical engineers engaged in basic and applied research on edible uses of soybean oil, meal, and protein. Food technologists are also required by the program in connection with formulation and organoleptic evaluation of edible products. Objectives of research on edible soybean oil are to identify undesirable flavor components of the oil, to develop basic information on the chemical changes and mechanisms involved in formation or suppression of these components, and to apply the knowledge gained to the development of edible soybean oil having improved oxidative, thermal, and organoleptic stability. Objectives of research on soybean meal and protein are to obtain basic information on the characterization of proteins, enzymes, and other components of soybean meal and to apply the knowledge gained to solution of problems encountered in processing and utilization of soybean meal and protein in food products for foreign consumption.

The Federal scientific effort for research on utilization of soybeans in foods totals 30.3 scientist man-years. Of this number, 7.0 are devoted to chemical composition and physical properties; 14.0 to flavor; 2.4 to color, texture and other quality factors; .5 to microbiology and toxicology; and 6.4 to technology--process and product development.

Research at Peoria, Illinois, on chemical composition and physical properties (5.6 scientist man-years) includes basic studies on the phenomenon of heat-gelation of alcohol-washed soybean protein and investigation of mass spectroscopy in elucidation of the chemical and molecular structure of glyceride oils and their derivatives. Grants (1.4 scientist man-years) have been made to the University of Minnesota, Minneapolis, Minnesota, for a study of antinutritional factors in soybeans; and to the University of Illinois, Urbana, Illinois, for physiological studies on gastrointestinal effects of soybean protein foods.

Research at Peoria, Illinois, on flavor (12.8 scientist man-years) emphasizes basic and applied studies on selective hydrogenation as a means of stabilizing soybean oil by removal of linolenate. The work includes chemical, physical, and organoleptic evaluation of edible soybean oil products. A research contract (.8 scientist man-year*) is in effect at Rutgers, The State University, New Brunswick, New Jersey, for basic studies on heterogeneous catalysts. In addition, a contract is in effect with the University of Illinois for studies of the mechanism of homogeneous catalysts of hydrogenation by organometallic catalysts. A portion of this effort (.4 scientist man-year) is allocated to research on food uses of soybean oil. During the year, the University of Illinois, Urbana, Illinois, completed a research contract covering basic research on homogeneous catalysts.

Research at Peoria, Illinois, on color, texture and other quality factors (2.1 scientist man-years) is devoted to basic studies of the influence of minor constituents of the soybean on the flavor and other edible qualities of soybean protein food products. A research contract (.3 scientist man-year) at the University of Illinois, Urbana, Illinois, provides for investigation of factors possibly present in soybeans that could cause digestive disturbances.

Research on microbiology and toxicology conducted at Peoria, Illinois, (.5 scientist man-year*) is concerned with a survey to estimate the incidence of aflatoxin in commercial samples of soybeans.

Research at Peoria, Illinois, on technology--process and product development (6.4 scientist man-years) includes engineering studies on production of full-fat soy flour by processes suitable for use in developing countries and

*Work covers more than one commodity; only effort allocated to soybeans is included in total.

on pilot-plant-scale hydrogenation of soybean oil with new selective heterogeneous catalysts. The work on full-fat soy flour is supported by the Agency for International Development and involves cooperation with UNICEF.

The Department also sponsors research on food utilization of soybeans conducted by foreign institutions under grants of PL 480 funds. Research on chemical composition and physical properties involves grants to the University of Tokyo, Tokyo, Japan, for studies on soybean sterols in defatted meal (5 years, 1963-1968); to Kagawa University, Takamatsu, Japan, for investigations of enzymatic hydrolysis of soybean oligosaccharides (3 years, 1966-1969); and to the Weizmann Institute of Science, Rehovot, Israel, for investigations on glycoproteins of soybean meal (5 years, 1967-1972). During the reporting period, research was completed on complexes between soybean protein and other components of the meal at the Weizmann Institute of Science, Rehovot, Israel.

Research on flavor is conducted under a grant to the University of Tokyo, Tokyo, Japan, for investigations on the flavor components of enzymatically or chemically modified soybean meal and proteins (4 years, 1964-1968). During the year, studies were completed at the University of Granada, Granada, Spain, on the effect of processing on frying quality of soybean oil; at Toyo University, Kawagoe, Saitama-ken, Japan, for research on hydrogenation of soybean oil; and at Experiment Station for the Fats and Oils Industry, Milan, Italy, for studies on certain metal chelate compounds as catalysts for selective hydrogenation of soybean oil.

Research on color, texture and other quality factors involves a grant to Sugiyama Chemical Research Institute, Tokyo, Japan, for basic studies on the color reversion of soybean oil (4 years, 1964-1968).

Research on microbiology and toxicology involves grants to the Japan Tofu Association, Tokyo, Japan, for studies on the use of U. S. soybeans for making tofu (5 years, 1963-1968); to Institute of Chemistry, Academia Sinica, Taipei, Taiwan, for investigation on preparing Chinese cheese from soybeans (5 years, 1963-1968); to Noda Institute for Scientific Research, Noda-shi, Chiba-ken, Japan, for studies on improved strains of Saccharomyces rouxii for making shoyu and miso (5 years, 1963-1968); to Japan Shoyu Research Institute, Tokyo, Japan, for comparative evaluation of U. S. and Japanese soybeans and processing methods for making soy sauce (3 years, 1965-1968); and to Tokyo University of Education, Tokyo, Japan, for basic studies on development of foods from enzymatically treated soybean protein concentrates (3 years, 1965-1968). During the year, research was completed at the Central Miso Institute, Tokyo, Japan, on miso made from dehulled soybean grits, and at the Bar-Ilan University, Ramat Gan, Israel, on miso-type food products for use in Israel.

Research on technology--process and product development involves a grant to the University of Tokyo, Tokyo, Japan, for evaluation of U. S. soybeans and processing for the manufacture of dried tofu (3 years, 1966-1969). During the reporting period, research was completed at the Israel Institute of Technology, Haifa, Israel, for evaluation of the quality of isolated soybean protein for use in Israeli foods.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 2.6 scientist man-years is devoted to research on food uses of soybeans.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Mass spectroscopy of glyceride oils and derivatives. Mass spectroscopic analyses of products of the incubation of linoleic acid in the presence of lipoxidase and of water and oxygen, one of which was labelled with heavy oxygen, proved that oxygen incorporated into the products comes from gaseous oxygen. A computer program was written that permits automatic direct conversion of the output of the mass spectrometer, obtained as a punched tape, to the final graphical plot of normalized intensity against mass number. By use of a one-piece all-glass apparatus for collection of volatile constituents, which eliminates any possibility of material being emitted from or absorbed by grease in joints and stopcocks, the presence of hydrocarbons of low molecular weight in autoxidized soybean oil was confirmed. A new field ionization source has proved useful in identification of compounds, such as alcohols and highly branched hydrocarbons, which do not form good molecular ions. An example is methyl 18-hydroxystearate, which has a normal mass spectrum different from that expected for a long-chain alcohol.

2. Basic studies on soybean protein. Hydrolysis of material extracted from isolated soybean protein by 86 percent ethanol yielded sugars identified as glucose, galactose, rhamnose, arabinose, xylose, and glucuronic acid. These sugars were also identified in the hydrolysis products of a presumed saponin fraction. Allantoinase was isolated from soybean meal, and evidence was obtained that allantoinase may be more stable to heat than urease. Methods were devised for recovering 11S protein from aqueous extracts of soybean meal by cold precipitation. Increasing temperature of extraction from 25° to 40° C. resulted in increased amounts of 11S in the extracts and in nearly twofold increase in yield of 11S precipitates on cooling. By use of known procedures for separating other proteins, the 2S, 7S, and 15S impurities, an 11S protein fraction was obtained in 92-95 percent purity. Remaining 5-8 percent (the 7S impurity) was separated by gel filtration to yield an 11S protein homogeneous by ultracentrifugation. Soybean proteins can be solubilized at pH 4.5 by using salt solutions. Maximum extraction occurred at 0.7N with NaCl and at 0.3N with $CaCl_2$.

3. Minor constituents of soybeans. These studies are being conducted by several foreign institutions under PL 480 grants. In research completed at the Weizmann Institute of Science, Rehovot, Israel, enzymatic degradation studies of the glycopeptide isolated from soybean hemagglutinin indicate that mannose residues are alpha-linked and N-acetyl glucosamine residues are beta-linked. Periodate oxidation studies were initiated to elucidate the structure of the glycopeptide. Four distinct hemagglutinins were isolated from soybean meal by diethylaminoethyl cellulose chromatography. The most abundant hemagglutinin is identical with the previously described purified hemagglutinin. All four hemagglutinins are similar in amino acid composition and are glycoproteins containing mannose and glucosamine.

At the University of Tokyo, Tokyo, Japan, confirmatory evidence for acylated steryl glucosides in soybeans was obtained by synthesis of 6-O-palmitoyl-D-glucoside. The synthetic compound and the acylated steryl glucoside fraction isolated from soybeans were identical by infrared analysis and thin-layer chromatography. Differences in melting points, optical rotations, and elementary compositions were observed but appear to result from the mixture of fatty acids (C_{14}-C_{22}) occurring as the acyl group in the material isolated from soybeans. The glucosidic linkages in sterol glucosides and acylated sterol glucosides of soybeans appear to be of the beta form on the basis of their optical rotations when compared with synthetic compounds known to be of the beta configuration. The Florisil column chromatographic procedure for fractionation of soybean sterols has been improved to permit separation into free, glucoside, acylated glucoside, and esterified forms of the sterols. Fourteen U. S. varieties of soybeans were analyzed by the improved procedure. Work is continuing in attempts to remove nonsterol impurities which interfere with colorimetric determination of the different forms of the sterols.

Preliminary results have been obtained on the digestibility of soybean oligosaccharides through in vitro enzymatic studies at Kagawa University, Takamatsu, Japan. Of 17 strains of Escherichia coli grown in the presence of raffinose, only two strains appeared to metabolize the sugar. One of these strains also consumed stachyose. Strains consuming raffinose produced acids causing a drop in pH from 7.0 to 5.4. Examination of the E. coli strains for α-galactosidase activity, as measured by decomposition of melibiose, indicated that the enzyme was primarily intracellular.

In other research at Kagawa University, Takamatsu, Japan, analysis of six U. S. and three Japanese varieties of soybeans showed that hexane-extracted soybean meal averaged 6.4 percent sucrose, 1.3 percent raffinose, 4.8 percent stachyose, and traces of mono- and pentasaccharides. These sugars were shown to be the source of the toasted taste acquired by soybean meal when it is processed for feed. Autoclaving of defatted soybean flakes caused a decrease in total sugar content, an increase in reducing sugars, a decrease in nonreducing sugars, and a decrease in available lysine. It was also shown that soybean oligosaccharides are partially hydrolyzed at pH 4.3,

the isoelectric point of soybean globulins. Work on this project was completed in the past year. Results included a detailed chromatographic analysis of the kinds and amounts of sugars in soybeans.

B. Flavor

1. Selective hydrogenation - homogeneous catalysis. By use of radioactive tracers, evidence was obtained that in hydrogenation of polyunsaturated fatty esters with $Fe(CO)_5$ as catalyst, the diene-$Fe(CO)_3$ complex is an essential intermediate and accounts for the high selectivity observed. On the other hand, methyl oleate was readily hydrogenated with $Fe(CO)_5$ as catalyst with no formation of complex. In mixtures, diene hydrogenation predominates. These findings were confirmed by analog simulation of the kinetics. If complex alone is used as catalyst, simulation showed that the direct reduction path from linoleate to monoene (i.e., not involving complex as intermediate) becomes important. Hydroformylation (oxo reaction) of vegetable oils and unsaturated fatty esters carried out with hydrogen, carbon monoxide, and dicobalt octacarbonyl resulted in addition of -CHO or $-CH_2OH$ groups, hydrogenation of polyenes to monoenes, migration and isomerization of the residual double bond. The isomerized bond is found at various positions along the fatty acid chain with a significant amount in the terminal position. Such isomerization is difficult to achieve by any other means. Conversion of fatty esters to oxo products varied from 42 to 89 percent.

Study of catalytic activity of Pt-Sn complexes under a contract with the University of Illinois showed that solvents displaying minimum capacity to coordinate with the metal were the most favorable for use in homogeneous hydrogenation. Complexes of Pt, Pd, and Ni with $(C_6H_5)_3P$ or $(C_6H_5)_3As$ were effective catalysts for hydrogenation of methyl cis,cis-9,15-octadecadienoate to produce mostly trans monoenes. This result indicates that the double bonds migrated to become conjugated and were then hydrogenated. Complexes of the type MX_2 $(QPhn)_2$, (M = Pt or Pd, X = halide, Q = phosphine or arsine when n = 3 and S or Se when n = 2, Ph = phenyl) catalyze the hydrogenation of polyolefins only in the presence of stannous chloride. Complexes of type PtX_2-(bidentate diene) also catalyze the hydrogenation of polyolefins. The product is the monoene in all hydrogenations studied. Kinetics of homogeneous isomerization of 1,5-cyclooctadiene catalyzed by $PtCl_2(PPh_3)_2$ plus $SnCl_2$ suggests that isomerization occurs in two consecutive reversible first-order reactions. $SnCl_2$ is essential for the isomerization process. It is suggested that it activates the platinum catalyst by being coordinated to it through the ligand $SnCl_3^-$.

During the year, research was completed by the Experiment Station for the Fats and Oils Industry, Milan, Italy. The final report has not yet been received.

2. Selective hydrogenation - heterogeneous catalysis. Partial hydrogenation of soybean oil using commercial copper-chromium catalyst was successfully scaled up to 15-gallon batches in the pilot plant. Linolenate-linoleate selectivity ratios of about 12 were achieved. During hydrogenation, linoleate content remains essentially constant while linolenate content is reduced to about 1 percent. It was found that heat treatment alone was effective for activating commercial copper-chromium catalysts so they would perform satisfactorily at comparatively low pressures (ca.30 p.s.i.) required for selective hydrogenation. Furthermore, active catalysts could be used five successive times without reactivation if they were kept slurried in soybean oil between uses. Cu content of oil increased considerably during hydrogenation. If the oil was bleached, deodorized, treated with citric acid (0.1%), and filtered, copper was reduced to about the level in the original unhydrogenated oil (0.02 p.p.m.).

Laboratory studies on the use of copper-chromium catalysts to selectively hydrogenate soybean oil showed that linolenate could be reduced to less than 1 percent with either laboratory or commercially prepared catalysts. Linolenate selectivity ratios (K_{Le}/K_{Lo}) ranged from 6 to 13. No stearate was formed. Trans isomers produced varied from 7 to 12 percent. Except in the trans isomers, most (90% or more) of the double bonds remaining after hydrogenation were located in their original position. Trans bonds showed extensive migration. A rapid, accurate procedure was developed for gas chromatographic determinations of the fatty acid composition of 2-3 microliter samples of vegetable oils. The micro-technique combines trans-esterification and sample injection into a single operation. Fatty acid synthesis in green soybeans was studied by incubating slices of freshly picked beans with acetate-1-C^{14} and then measuring the isotopic carbon incorporated into the fatty acids as a function of time. After 2 hours, the specific activity of the polar lipid fraction was 20 times that of neutral lipids. Results indicate that initial desaturation occurs on a 12- or 14-carbon chain, followed by chain elongation to hexadecenoic and oleic acids.

Under a contract with Rutgers University, basic studies on hydrogenation catalysts from leached vermiculites and on infrared absorption of fatty methyl esters adsorbed on catalytic surfaces are essentially completed, and results are being interpreted.

Under a PL 480 grant, research at Toyo University, Kawagoe, Saitama-ken, Japan, shows that copper-nickel-kieselghur catalysts are more active for hydrogenation when activated by dry rather than wet procedures. In the absence of oil or other liquids, optimum activity appears to be achieved when the catalyst is reduced at 190-195° C. for 20 minutes. Manganese enhances activity of copper-chromium or copper-nickel catalysts. Selectivity of copper-nickel for linolenate is not increased by manganese. Isoamyl gallate and citric acid improve resistance to oxidation at 62-63° C. but not at 200° C. of partially hydrogenated soybean oil (iodine value 118). In studies on continuous hydrogenation, the designed equipment failed to

perform as well as batch operations in a larger vessel. A larger scale continuous hydrogenator is now being designed.

3. Evaluation of edible soybean oil products. Studies on evaluation of edible soybean oil confirmed previous findings that residual traces of metal in oils hydrogenated with copper-chromium catalysts adversely affected stability and quality. Preliminary tests showed that heating such oils with citric acid gave products having substantially improved flavor and stability. For the satisfactory quantitative determination of trace metals in oil, ashing appears to be the most effective means of concentrating trace metals in samples for analysis. The amount of volatile hydrocarbons in edible soybean and cottonseed oils shows high correlation with flavor score and peroxide content of the oils. Lipoxidase studies basic to oil processing have established that some enzymes are very specific for the pentadiene system and induce oxidation only on the 13th carbon of linoleic acid. This added oxygen is derived from air and not from the aqueous reaction system. Chromatography showed that the oxidation products contained both hydroperoxide (60%) and a mixture (40%) of oxidative dimer and other polar compounds. Commercial enzyme preparations varied widely in specificity and activity.

At the University of Granada, Granada, Spain, vessels of glass, aluminum, and steel were studied to determine their effect on the stability of fats when used five times for deep-fat frying. Oils tested were pure olive oil and soybean oil refined in Spain. Hake, a fish similar to cod, was used as the test material. Taste panel results indicated that the third and fifth fryings of hake in soybean oil in glass or steel vessels were of better quality. The fifth fry of hake in pure olive oil in an aluminum vessel was best. The influence of antioxidants is being studied and it has been determined that with pure olive oil the optimum quantity of antioxidant that can be added to pure olive oil is 0.6 percent when frying at 180° C. (356° F.) in glass with 1 liter of oil and 1 kilogram of potatoes. Phytic acid and citric acid are being studied as metal inactivators both alone and with antioxidants. These studies, conducted under a PL 480 grant, were completed during the year.

4. Flavor components of soybean meal and protein. The flavor components of defatted soy flakes (0.14% fat content--official analysis) have been found in the bound lipids and in a nonlipid fraction. The flakes were found to contain about 4 p.p.m. of volatile carbonyl compounds. The main component is hexanal, but acetone, acetaldehyde, and an unidentified dienal were also isolated. The bound lipid fraction of either raw or toasted soybean flakes had an astringent taste and a hydrocarbon-like flavor. The nonlipid fraction was bitter. It was observed that the "beany flavor" of raw defatted meal disappeared very rapidly during extraction with alcohol. Extraction of lipids of laboratory-prepared defatted soy flakes with an azeotropic mixture of a hexane-absolute ethanol yielded nearly 3 percent lipids. Composition of crude lipid was 2.2 percent P, 1.05 percent N, and

9 percent carbohydrate. Phospholipids, triglycerides, and sterol derivatives, in decreasing order, were the major constituents. Fractionation of the crude lipids into distinct classes gave phospholipids having an oily, waxy taste and none of the flavor of soy flour. A flavor fraction isolated from the crude lipid extract had a strong hydrocarbon flavor, intense aftertaste and a throat-catching sensation associated with objectionable flavor of the bound lipids.

Under a PL 480 grant to the University of Tokyo, Tokyo, Japan, the following proteolytic enzymes were used to modify the flavor of isolated soybean protein: pepsin, morsine, coronase, and rapidase (acid proteases); prozyme, thermoase, and takadiastase (neutral proteases); and alkaline proteinase of Bacillus subtilis. Coronase and pepsin gave a bitter product. Pronase, bioprase, and alkaline protease of Bacillus subtilis gave a bitter and astringent product. Morsine, rapidase, takadiastase-SS and thermoase gave better flavored products because the bitter and astringent flavors were substantially reduced. Morsine (2 hours' incubation) was judged to give the best flavored products. Combinations of enzymes were no better than morsine-treated products. Takadiastase-SS gave the highest amino-nitrogen values. Hydrolysis with morsine and fractionation by gel filtration and amino acid analyses gave high yields of arginine, leucine, phenylalanine, glutamic acid, lysine, aspartic acid, and tyrosine, trace amounts of cystine and methionine, as well as 13 peptides and 8 unknowns.

C. Color, Texture and Other Quality Factors

1. Flatulence factor of soybeans. In contract research at the University of Illinois, it was shown that fermentation of soybean oligosaccharides in the ileum and colon is apparently one cause for flatulence from soybeans. In vivo studies with anesthesized dogs showed that syringic acid (major phenolic acid in soybean flour) inhibits flatulence in the colon and ileum, whereas genistin has little effect. In vivo production of flatus from tempeh is much less than that from equivalent amounts of soybean flour. Removal of low molecular weight constituents by soaking and cooking effect this result. Demonstration that intestinal microflora of dogs and humans produce gas from soybean oligosaccharides provides evidence that substrate is a primary factor in flatulence. Chromatographic experiments show that E. coli and anaerobic microflora of the dog intestine degrade the soybean oligosaccharides sequentially to monosaccharides followed by the production of gas and concomitant disappearance of carbohydrate components. Similar results were obtained with soy flour. Improved in vitro assay procedures for measuring gas production reveal that with proper control of cultures and media, both anaerobic and aerobic bacteria produce gas from carbohydrates.

In studies under a PL 480 grant to Sugiyama Chemical Research Institute, Tokyo, Japan, it has been shown that the tocopherol content of extracted crude soybean oil decreased to less than 30 percent of the normal value as the moisture content of the beans was increased to 18-20 percent

(coefficient of correlation 0.93). Soybean salad oil obtained from high moisture beans rapidly exhibited the color reversion phenomena after short periods of storage. The quantity of tocored (an oxidation product of tocopherol) in crude soybean is at a maximum when the moisture level of extracted beans is at 18 percent. Refining of the crude oil removed the greater part of the tocored but about 30 percent of a precursor or a "colorless derivative" of tocored remained in the oil. The conversion of this "colorless derivative" to tocored is reportedly the cause of color reversion in stored soybean salad oil. Tests show that the tocopherol content of salad oil before and after color reversion remains the same. No color problem develops when beans of less than 12 percent moisture are processed. Drying of the rolled flakes is not effective. Distribution of tocopherol within various fractions of soybean cotyledons and hypocotyls has been determined on whole beans and for germinated seeds. Current studies deal with the interconversion of tocored and its colorless derivatives.

D. Microbiology and Toxicology

1. Aflatoxin investigations. Studies on toxins produced by molds are important to utilization of soybeans in foods. Results are reported under "Corn Utilization - Feed," subheading B-1.

2. U. S. soybeans for making tofu. Under a PL 480 grant at the Japan Shoyu Research Institute, Tokyo, Japan, conditions for use in the experimental studies on dried tofu, sometimes called frozen tofu or kori-tofu, have been established. The preparative scheme and conditions for each step, the conditions for study of the browning reaction of stored kori-tofu, and the preservation of the swelling capacity of stored kori have been outlined. Selected varieties have been shipped to Japan under another project and they will be tested, in part, for kori-tofu.

Previous studies by the Japan Tofu Association, Tokyo, Japan, have shown that Hawkeye is among the best, if not the best, of varieties for making fresh tofu. Selected and new varieties have been gathered and shipped to Japan for direct comparison with Hawkeye. The protein in this variety has been shown to coagulate slower than most of the proteins of other varieties. Also, a softer and more gelatinous tofu results. Varieties differ in the range of added coagulant that gives a good product. Hawkeye has a wide range. The relation of phytic acid to the coagulation is now under investigation. In calcium-precipitated protein, the phosphorus-nitrogen ratio is higher than in "sodium"-precipitated protein. Thus, phytic acid content does appear to be related to coagulation of tofu. These studies are being conducted under a PL 480 grant.

Research at the Tokyo University of Education, Tokyo, Japan, conducted under a PL 480 grant, shows that trypsin inhibitors in soybean protein may affect the development of new foods from enzymatically treated soybean

concentrates. Water-extracted soybean protein from Hawkeye soybeans was successfully fractionated into five reproducible fractions by gel filtration techniques with Sephadex G-200. The trypsin inhibitor was concentrated in the fourth fraction and the fifth was devoid of protein. Each of the four protein fractions show different ultracentrifugal patterns. Fraction four had a considerably higher percentage of sulfur-containing amino acids. From fraction four, four trypsin inhibitive fractions have been isolated which probably correspond to those found at NU.

3. Studies on miso and shoyu. These studies are being conducted by several foreign institutions under PL 480 grants. At the Japan Shoyu Research Institute, Tokyo, Japan, work is continuing on the use of soybean grits, Japanese and American soybean meal, and alcohol-washed meal as starting material for soy sauce--shoyu. In pilot studies based on procedures developed at the Sendai Test Plant, seven of eleven plants encountered formation of clods in the steaming and cooking of grits for shoyu. American defatted soybean meal could be fermented by the usual procedure, but it is a difficult raw material to use. Further studies will be undertaken to find better methods of treatment. Initial sample of alcohol-washed soybean meal was damaged and a second shipment is being ordered.

Successful matings of Saccharomyces rouxii have been found and the conditions for making mating established at the Noda Institute for Scientific Research, Noda-shi, Chiba-ken, Japan. This now permits hybrids to be made. Several diploid strains thus far studied show growth in an 18-percent NaCl medium. At the same time, studies on flavor components produced by S. rouxii were investigated and one of the major components is β-phenethylalcohol. This is also formed by the hybrids. Two other important flavor compounds in shoyu produced by yeast are p-ethylguaiacol and p-ethylphenol. However, these compounds in shoyu are made by species of Torulopsis rather than S. rouxii.

Evaluation of miso samples at the Central Miso Institute, Tokyo, Japan, prepared with Aspergillus oryzae by fermentation of defatted soybean flakes and various cereals, when fed to weanling rats, showed that miso protein cannot sustain normal growth and development. This is due in part to the high sodium chloride content of the diets containing miso. Determination of the free amino acids in miso reveals the absence of methionine; but supplementation of the rat diet with l-methionine failed to correct the imbalance of miso protein as evaluated by its protein efficiency ratio. Preliminary results suggest that possibly threonine might be limiting. The amounts of three vitamins, thiamine, riboflavin, and niacin, in the finished preparations were found to be from 65-84 percent of the vitamins in the starting materials. However, none of these are limiting factors because diets were fortified with each of them. The cause of part of the poor nutritional value is, as yet, unknown.

In other research at the Central Miso Institute, it was found that concentrates of the water-soluble byproducts of miso production from soybean grits can be used to grow Aspergillus oryzae as a source of amylase and proteinase used in the anerobic stage of miso fermentation. Economic benefits might be realized from such use of these water-soluble materials which represent as much as 10 percent of the dry soybeans. Maximum proteinase activity occurred in 4 days and maximum amylase activity peaked at 6 days. During a 3-day fermentation the total sugar decreased from 2.6 percent to 0.2 percent. Testing of varieties and strains of soybeans for making miso indicate the following varieties are best: Kanrich, M-1, Mandarin, Traverse, and breeding strains AX-80-39 and AX-84-100.

4. Chinese cheese (sufu). Under a PL 480 grant to the Institute of Chemistry, Academia Sinica, Taipei, Taiwan, studies on the extracellular enzymes of Actinomucor elegans, the principal fungus used in the preparation of soybean cheese, have demonstrated the presence of two proteolytic enzymes--one resembling trypsin and the other chymotrypsin. These were demonstrated on a synthetic medium. Investigations also demonstrated the presence of dipeptidases. Additional studies indicate that Actinomucor, as well as several other molds used in the Chinese cheese fermentation, produce a phospholipase. Substitutes for calcium sulfate for coagulating soybean protein were investigated. When canning was used as a means of preserving Chinese cheese, a very fine, smooth, better textured and tasting product could be made. Seasoning of the canned material involved the use of propionic acid, garlic and Kaoliang wine. Considerable study was devoted to the chemistry of the cell wall of the fungus which becomes part of the cheese. Seven amino acids (aspartic, glutamic, threonine, glycine, alanine, valine, leucine, and/or isoleucine) were found, as well as glucose and glucosamine.

E. Technology--Process and Product Development

1. Full-fat soybean flour. In the village or hand process for making full-fat soy flour, microbiological studies show that care is needed during the drying step to obtain a product having a low bacteria count. Drying in the open air and in direct sunlight had an antimicrobial effect and was superior to indoor drying. Total drying time should be limited to 36 hours. Rat-feeding tests, conducted on several lots of full-fat soy flour produced under varied conditions by the village process, indicated nutritive values and protein retention efficiencies comparing favorably with casein. Refinements in hand-operated flour mills has resulted in a finer flour, giving rise to a smooth, stable soy beverage when homogenized in water. In a second process, the extrusion cooking of soybeans, conditions have been established for the satisfactory operation of the extruder to produce full-fat soy flours. A heat treatment has been developed which deactivates the lipoxidase enzyme to give a stable full-fat soy flour free of rancid odor and flavors. This research is supported by the Agency for International Development.

2. Quality of isolated protein for use in Israeli-type foods. Under a PL 480 grant to the Israel Institute of Technology, Haifa, Israel, studies on the processing variables and pilot-plant conditions that affect yield, color, nutritive value, and organoleptic properties of soy protein isolates (SPI) have been completed. The most rapid and complete extraction of protein from dehulled, defatted soy flour was obtained by extraction with 0.03 N calcium hydroxide solutions, at 55° C., for 30 minutes. SPI was recovered by centrifugation of the precipitated curd at pH 4.6. SPI has excellent functional properties for the spray-drying of bananas and in maintaining banana flavor in storage. The considerable loss of loaf volume of 6 percent SPI in bread was counteracted with the addition of lecithin. Studies on the use of SPI in the manufacture of protein cheeses is being investigated. Hard and soft cheeses have been made. However, difficulties associated with the clotting and ripening processes have been encountered. Rheological and organoleptic properties may vary considerably.

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CRAMBE UTILIZATION - INDUSTRIAL PRODUCTS
Northern Utilization Research and Development Division, ARS

Problem. Crambe, a new oilseed crop commercialized in 1965, is the first plant included in the research program on new crops to achieve this status. Crambe seed oil is rich in erucic acid. Several industrial uses already existed for erucic acid as well as for imported rapeseed oil, which formerly was the only source of this acid. However, the greatest impetus to commercialization of crambe was perhaps the discovery that crambe oil performed better than any other known material as a lubricant in continuous casting of steel. This situation emphasizes the importance of finding the most advantageous specific applications that can contribute to utilization of any new crop in its own right.

To insure optimum development of crambe as a new economic crop, possible markets for crambe oil and erucic acid must be explored and those with the greatest industrial potential must be identified and made effective. This goal can be reached through a program of basic and applied research that will provide more information on the chemical and physical properties of crambe oil, its component fatty acids, and their chemical derivatives. When promising leads to possible industrial applications are found, product and process development research will be needed to evaluate the potential and to provide facts and data essential for commercial adoption of crambe oil products in new end uses.

USDA AND COOPERATIVE PROGRAMS

The Department conducts a continuing, long-range program of research involving analytical and organic chemists and chemical engineers engaged in basic and applied research on industrial utilization of crambe oil. The objectives of the work are to obtain new information on reactions of crambe oil and its component fatty acids and to use this information to develop new products for use by the chemical and other industries.

The Federal scientific effort for research on industrial utilization of crambe totals 5.5 scientist man-years. Of this number, 4.2 are devoted to chemical and physical investigations to improve products and 1.3 to technology--process and product development.

Research at Peoria, Illinois, on chemical and physical investigations to improve products (4.2 scientist man-years) is concerned with chemical modification of crambe oil and its component fatty acids, especially erucic acid, to obtain chemical intermediates or derivatives having desirable properties for industrial use.

Research on technology--process and product development involves a research contract (1.3 scientist man-years) with Southern Research Institute, Birmingham, Alabama, for studies on preparation and evaluation of polyamide resins derived from crambe oil.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 1.5 scientist man-years is devoted to research on industrial and feed uses of other oilseed crops, including crambe.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical and Physical Investigations to Improve Products

1. Chemical derivatives from crambe oil. A procedure has been found for convenient separation of vinyl 2-methylpentyl brassylate (VMB) into a fraction free of divinyl brassylate (DVB) and a fraction rich in DVB. VMB as a comonomer imparts appreciable plasticization to poly(vinyl chloride) (PVC), although low-temperature properties of molded pieces containing it are inferior to those containing external plasticizers such as 2-methylpentyl brassylate and 2-ethylhexyl phthalate. DVB-rich VMB gave softer products than pure VMB, but molding and tensile properties were poor. Evaluation of 12 diesters (butyl to decyl), prepared from mixed diacids obtained via ozonolysis of crambe free fatty acids, as plasticizers for PVC showed that the "azela-brassylates" and the brassylates impart almost identical tensile properties to the vinyl resins, have comparable heat and light stability, and have excellent low-temperature properties. The bis(2-methylpentyl) azela-brassylate compares quite favorably with commercial dioctyl sebacate as a low-temperature plasticizer for PVC; in addition, the mixed ester has much better light stability. Five disubstituted amides of acids in selectively hydrogenated crambe oil have been prepared for evaluation as PVC plasticizers. Tetracyano ethylene oxide adducts have been prepared from methyl erucate and methyl brassidate (trans isomer of erucate). Acid-catalyzed methanolysis of the adducts gives nearly quantitative yields of 2,5-dicyano-2,5-dicarbomethoxy-3(11-carbomethoxyundecyl)-4-octyltetrahydrofurans instead of the expected esters. Evidence suggests that the methanolysis reaction is sterically controlled to provide major products with carbomethoxy groups trans to vicinal alkyl groups. Similarly the adducts are hydrolyzed on silica gel to dicyano diamides, but the parent trans-tetracyano derivative hydrolyzes much more slowly than the cis-isomer.

B. Technology--Process and Product Development

1. Polyamide resins from erucic acid. In contract research at Southern Research Institute, procedures were developed for mechanically reducing large chunks of nylon 1313 polymer to obtain the small fragments needed to permit molding and other evaluation studies to proceed. Its melt-flow properties were similar to the commercial nylon 11 and nylon 610. Commercial injection molding of nylon 1313 was conducted with commercial-type

equipment, using several different extruder dies. There was no operating difficulty. Polymer filled the mold well, indicating good flow characteristics. A stabilizer against thermal and oxidative deterioration is desirable to prevent discoloration. When properties of nylon 1313 were compared to those of commercial nylon 11 and nylon 610, the following conclusions were drawn: (1) nylon 1313 appears suitable for a number of commercial products; (2) there were no problems in processing nylon 1313 or any deficiencies in its properties that would restrict its usage; and (3) the lower water absorption of nylon 1313 may be a significant advantage. Small amounts of nylon 13 have been prepared by melt polymerization of 13-aminotridecanoic acid.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

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CRAMBE UTILIZATION - FEEDS
Northern Utilization Research and Development Division, ARS

Problem. The economic value to the farmer and to industry of any oilseed crop is much greater if the meal left after extraction of the oil can be utilized as a palatable and nutritious feed for animals. Crambe, a new and only recently commercialized oilseed crop developed under the new crops research program, yields a meal that, on the basis of amino acid analysis, should be an excellent feed product. However, as is true for other oilseed meals, such as soybean meal, suitable processing is needed to realize fully the anticipated nutritional qualities and to insure maximum acceptability to different types of animals. Needed research includes isolation and characterization of components of crambe meal that are important to nutritional value, flavor, and other essential qualities of a feed. The fate of these components during processing must be investigated in order to learn how to preserve desired components and eliminate or minimize the effects of deleterious ones. Finally, engineering studies are required to translate laboratory findings into economical and practical processes for industrial use.

USDA AND COOPERATIVE PROGRAMS

The Department maintains a continuing, long-range program of basic and applied research involving analytical and organic chemists and chemical engineers engaged in study of the components of crambe meal and in development of effective processes for converting crambe seed to oil and palatable, nutritious meal for animal feed.

The Federal scientific effort for research on feed uses of crambe totals 7.6 scientist man-years. Of this number, 5.8 are devoted to chemical composition and physical properties and 1.8 to technology--process and product development.

Research on chemical composition and physical properties is conducted at Peoria, Illinois, and is concerned with studies on components of crambe meal such as enzymes, other nitrogenous components, pigments, flavor principles, etc.

Research on technology--process and product development, also conducted at Peoria, Illinois, is devoted to engineering studies on processing crambe seed to oil and palatable, nutritious meal.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 1.5 scientist man-years is devoted to research on industrial and feed uses of other oilseed crops, including crambe.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Crambe enzymes. Treatment of epi-progoitrin (epi-PG) with ferrous ion in aqueous solution protected from atmospheric oxygen resulted in formation of nitrile (S)-1-cyano-2-hydroxy-3-butene and of a new compound, (S)-3-hydroxy-4-penteno-thionamide. Nitrile and thionamide in about 1:4 weight ratio were formed overnight at room temperature from epi-PG and 6-8 molar equivalent of ferrous ion. During first 7 hours of reaction, rate of production of thionamide was about same as loss of epi-PG; then the epi-PG was no longer detectable by UV absorption although thionamide formation continued, reaching maximum at about 24 hours. The isomeric (R)-thionamide obtained from rapeseed has about the same toxicity to mice as the (S)-thionamide from crambe. In an isolated enzyme system that converts epi-PG to (R)-goitrin, the addition of an amount of Fe^{++} equivalent to the iron content of crambe meal suppresses goitrin formation. Instead of goitrin, the enzymatic product is chiefly (S)-1-cyano-2-hydroxy-3-butene. This evidence suggests a role for Fe^{+2} in nitrile production in intact crambe meals.

2. Conversion products from epi-progoitrin (epi-PG). Continuing studies on toxic factors of crambe meal confirm the toxicity of isolated or concentrated nitriles by feeding tests on rats. Limited LD_{50} tests with mice showed toxicities of 25 to 100 mg./kilo. Liver damage is produced by some component in the nitrile mixture. Nitriles are more likely to be formed during autolysis of crambe meal than is (R)-goitrin. Results of rat feeding tests on a series of laboratory and commercially prepared crambe meals, some with carbonate treatment and some without, offer the following conclusions based on this experiment only: (1) rewetting processed meals is not deleterious and may be slightly beneficial, and (2) meals containing unhydrolyzed epi-progoitrin gave poorest growth response and most severe lesions in the liver and other body organs. However, defatted meal allowed to autolyze contains no epi-progoitrin but is far more toxic than any of the above.

B. Technology--Process and Product Development

1. Processing crambe to oil and meal. Rat feeding tests show that after treatment of crambe meal with soda ash, some growth inhibitory substances remained. Feeding tests on chicks also provided evidence that these meals were not as good as soybean meal for nonruminants. However, meal treated with soda ash continues to give good results in feeding tests with cattle. Weight gains were equal when the protein supplement was either all soybean meal or a 50-50 crambe-soybean meal mixture. When rats were fed autolyzed and nonautolyzed crambe meals at a 30-percent level, neither growth nor organ toxicity correlated with nitrile content of the meals. Residual

epi-progoitrin or goitrin was more directly associated with poor growth and resulted in larger livers, kidneys, and thyroids. Organs of animals fed meals free of epi-progoitrin were normal even though nitrile content was high. Soda ash improved growth when it accomplished destruction of epi-progoitrin.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

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Technology--Process and Product Development

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NEW CROPS UTILIZATION
Northern Utilization Research and Development Division, ARS

Problem. Farmers could achieve more economic use of their land if new and profitable crops were available for their choice that would have different end-use patterns from those presently grown. For example, it would be advantageous to develop a new oilseed crop yielding unique fatty acids that could find industrial use in applications for which acids from presently available domestic oilseed crops are unsuitable. To develop a new crop, three basic steps are involved: (1) survey of wild plants, in cooperation with plant scientists, to identify those having both potentially valuable components and promising agronomic potential for use in the United States; (2) detailed physical and chemical studies on components of interest to obtain clues to likely end uses; and (3) selection of the most promising species, followed by additional utilization research to explore uses and demonstrate industrial potential, as well as by additional agronomic research to establish proper cultural practices and to select the best strains and varieties. Only after these steps have been successfully accomplished can a proposed new crop be offered to agriculture and industry for introduction and development. Obviously, a program of this type is a long-range one. Yet, whether the future of agriculture involves conditions of surplus, of greater emphasis on foods and feeds, or of necessity for greater national self-sufficiency, the nation will benefit from availability of optimum, practical crop plants to serve its needs.

One of the most promising approaches is to search for plants whose seed oils contain potentially useful fatty acids that either are not now available commercially or must be obtained from foreign sources. However, for a new oilseed crop to achieve maximum utility and economic value, it is desirable to obtain, as a byproduct, a palatable and nutritious meal suitable for animal feeds. Thorough investigation is needed, therefore, to determine the probable utility of new oilseed meals as feeds; to discover the presence of possibly undesirable minor constituents; and to evaluate the prospects for successful processingof the oilseed to oil and acceptable meal.

Research on new crops has already revealed several promising plant sources of new products that should have valuable industrial uses. These products include water-soluble gums, pulp fibers, and oils containing unique fatty acids such as hydroxy-unsaturated acids, capric acid, epoxidized acids, and unusual long-chain fatty acids.

One new crop, crambe, has a seed oil rich in erucic acid, which is currently obtained from imported rapeseed oil. Crambe has recently achieved commercialization and the outlook for it to become an important crop is encouraging.

To find still other desirable new crops, continued screening and characterization research is needed. Evaluation of the potential of new materials discovered requires further work on their physical and chemical properties and reactions and on processing to obtain maximum recovery from source plants.

USDA AND COOPERATIVE PROGRAMS

The Department conducts a long-range, continuing program of research involving analytical and organic chemists and chemical engineers engaged in examination of uncultivated plants to find unusual and potentially useful components and in detailed characterization and evaluation studies of selected components that have the greatest industrial potential and that are obtainable from agronomically promising plants. Plants or seeds for this program are obtained by cooperation with Crops Research Division which procures material from domestic and foreign sources by means of collecting trips or from experimental plantings. Materials from abroad are also made available through Crops Research Division PL 480 projects providing for collecting activities by foreign investigators. All seeds and plants are submitted to a broad chemical screening program to identify sources of unusual and potentially useful components such as oils, fibers, and gums. Components of interest from plants rated by Crops Research Division as having a reasonable agronomic potential for the United States are characterized to obtain clues to areas of utilization of probable interest to industry. On the basis of the results, plants having the highest agronomic potential and containing components of greatest potential industrial value are selected for more intensive utilization research.

The Department maintains a continuing but limited program involving one professional analytical chemist who devotes a portion of his time to screening uncultivated plants to find possible sources of new amino acids and proteins and to study of amino acids and proteins of meals obtained from new potential oilseed crops.

Research on chemical composition, physical properties and structure is conducted at Peoria, Illinois, and includes conduct of the program on screening uncultivated plants for new oils, fibers, gums, and other components of potential value to industry; organic chemical characterization of selected components, especially new oils and fatty acids; and studies on properties of new plant fibers. During the year, studies were initiated on the composition of rotenone-containing extracts from Tephrosia vogelii.

The Federal program at Peoria, Illinois, includes 0.4 scientist man-year devoted to chemical composition and physical properties of feeds, and 9.2 SMY's on new oilseed crops as sources of industrial products. Of this number, 6.9 are devoted to chemical composition, physical properties and structure, and 2.3 to technology--process and product development.

The Department also sponsors research in this area conducted by foreign institutions under grants of PL 480 funds. Research on chemical composition, physical properties and structure involves grants to the Swedish Seed Association, Svalof, Sweden, to find new erucic acid oilseeds (5 years, 1963-1968); and to the Institute of General Chemistry, Warsaw, Poland, for studies on synthesis of glycerides from erucic and related fatty acids (5 years, 1967-1972). Research was completed during the reporting period for determination of glyceride structure of erucic acid oils at the Institute of General Chemistry, Warsaw, Poland.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 6.2 scientist man-years is devoted to research on industrial and feed uses of miscellaneous and new crops.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

I. Industrial Products

A. Chemical Composition, Physical Properties and Structure

1. Screening for new industrial oils. Screening of seeds for unusual oils and other constituents continues. During the period, 791 samples were received, of which 424 were new species. Screening analyses were performed on 777 samples and 362 oils were analyzed. Oil from Crepis alpina contained 75 percent crepenynic acid and is the richest source of this acid yet found. This acid was also found this period in additional species of Jurinea (13 and 36%) and Picris (46%), and in Lapsana communis (50%) and Crepis aspera (58%). Vernonia anthelmintica (224 samples) grown in 1966 ranged in oil content from 12-27 percent, and vernolic acid in oil from 37-78 percent, about the same as the 1965 crop. A large lot of Satureja hortensis seed from Washington contained 45 percent of oil with IV of 214 and linolenic acid content of 70 percent. Petroselinic acid of oils determined by ozonolysis procedures ranged from 43 percent (Bupleurum croceum) to 78 percent in Petroselinum crispum and 79 percent in Hedera helix. Advances in methodology has greatly increased the speed and effectiveness of screening. These include (1) adaptation of a microozonolysis procedure to achieve facile estimation of petroselinic and oleic acid components of the oils; (2) direct analysis of oils by high temperature programmed GLC; and (3) direct instrumental conversion of GLC data followed by processing with a digital computer which interprets data and prints out results. Cephalotaxus drupacea continues to be of interest in the anti-tumor screening; the alkaloid fraction from the seed was found to be active.

Continued research on single seeds and single plant selections at the Swedish Seed Association, Svalof, Sweden, has provided a maximum value of 66 percent C_{22} acids in seed oil from any of the species under study.

Variation in erucic acid content of Brassica carinata oil from single plants is not as great as that found for single seeds, but still suggests probable success in developing high erucic lines. The amount of oxazolidinethione derived from thioglucosides in 15 lines of crambe (10-12 mg./g. dry, fat-free meal containing pericarp) varied little, but, in four lines of B. napus, the variation was great enough (7-11 mg./g. dry, fat-free meal) to encourage further research in breeding for low thioglucoside content. In B. campestris, oxazolidinethione from the thioglucosides ranged from 0-6 mg./g. and volatile isothiocyanates from 5-23 mg./g. Development of B. campestris with no oxazolidinethione or isothiocyanate seems possible. Emphasis will be increased on breeding B. carinata for high erucic acid content and on the search for variation in thioglucoside content of high erucic oil producers. These studies are being conducted under a PL 480 grant.

2. Characterization of seed oils and component fatty acids. A new allenic fatty acid (-)-5,6-trans-16-octadecatrienoic acid was isolated from Lamium purpureum seed oil and characterized. Etherification of the hydroxyl group was found to occur where methyl 13-hydroxy-cis-9,trans-11-octadecadienoate (derived from Xeranthemum annuum seed oil) was treated with 0.1 N methanolic H_2SO_4. The trihydroxy acids of seed oils of three species of Chamaepeuce have been characterized. Cardamine impatiens seed oil has been shown to contain about 40 percent of the glycerides which have monoacetates of dihydroxy acids (mostly C_{22} and C_{24}) attached at α-positions of the glycerides and the β-position occupied primarily by C_{18} unsaturated acids. Two unusual triglycerides make up ca. 85 percent of Chamaepeuce afra seed oil. Each contains one of the trihydroxy C_{18} acids described previously; but in one fraction, each mole of trihydroxy acid is esterified with a mole of C_{18} unsaturated acid and a mole of C_{10}, C_{12} or C_{16} saturated acid. The other component has each mole of the trihydroxy acid moiety esterified with a mole of C_{16} saturated or C_{18} unsaturated acid and a mole of acetic acid. Fatty acids containing isolated double bonds in the 5-position were found in seed oils of other Ranunculaceae. Hence, the discovery that Caltha palustris seed oil contains three such acids suggests that this type of unsaturation may be a characteristic of this family. Analyses of kenaf juice obtained from plants grown at Peoria shows presence of about 20 percent reducing sugars, 2.7-3.8 percent nitrogen (85-95% appears to be non-protein nitrogen), and 20-30 percent ash in juice solids. Jarilla chocola produces edible fruits containing a protease resembling papain in that it responds to sulfhydryl activators.

Under a PL 480 grant to the Institute of General Chemistry, Warsaw, Poland, six seed oils high in esterified erucic acid (30-79%) have been analyzed for component triglycerides. The oils represent the genera Tropaeolum, Iberis, Alliaria, Peltaria, Raphanus, and Crambe. Partial (selective) enzymatic hydrolysis of the oils was followed by separation of the 2-monoglycerides. Gas-liquid chromatographic analysis of fatty acid esters

derived from whole oil as well as from the monoglyceride fraction provided data to allow calculation of the positions of fatty acids in the original triglycerides. Tropaeolum oil (79% erucic acid) contains 46 percent trierucin, but does not show the expected preference of erucic acid for the 1,3-positions; the other five oils do show such a preference. Four seed oils from the genera Tropaeolum, Crambe, Eryssimum, and Lobularia are being studied by another, more sophisticated method for triglyceride analysis. These oils have been separated into fractions containing a given number of double bonds per triglyceride. The total fatty acid composition of the individual triglycerides has been calculated, but the positions of the acids on glycerol is not yet known.

II. Feeds

Chemical Composition and Physical Properties

1. Components of autolyzed rapeseed meal. Studies have been made involving the structural characterization of the nitrile mixture obtained from a defatted, autolyzed rapeseed meal (Brassica napus). It has been shown that the unsaturated hydroxy nitrile and isomeric episulfides formed were enantiomers of the corresponding compounds derived similarly from crambe meal.

2. Feeding studies on new seed meals. Vernonia meal fed to rats for 90 days at a diet level of 25 percent caused some growth inhibition but no pathological effects. Adding methionine corrected two-thirds of the growth inhibition. Rats fed Euphorbia meal for 4 weeks grew normally, and no harmful effects appeared. These studies were conducted with the cooperation of the Pharmacology Laboratory at the Western Division.

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PEANUT UTILIZATION - FOOD

Southern Utilization Research and Development Division, ARS

Problem. Peanuts constitute a major cash crop in the Southern States and are in surplus. Because of their high price, domestically produced peanuts are used primarily in foods such as peanut butter, confections, bakery goods, and roasted and salted nuts. A critical problem in the utilization of peanuts, which has recently been made more clearly evident, is the sporadic contamination of peanuts by toxin-producing strains of common molds. The possibility of toxins entering foods intended for human consumption, as well as feedstuffs, is of the utmost concern. Intensified research is therefore urgently needed on the isolation, identification, evaluation, control, and inactivation or removal of mold toxins, such as aflatoxin, that may develop in peanuts and processed peanut products.

New-type food products and improvement in the quality and uniformity of existing products are needed to increase consumer acceptance and extend markets for peanuts; the average per capita consumption has been rather stable since World War II. The increased trend toward mechanical harvesting has necessitated the use of artificial means for curing and drying peanuts, with the result that processed peanuts and peanut products do not always possess the same desirable flavor and physical properties as peanuts that have been cured slowly in the field. Information is needed on the physical and chemical characteristics of those chemical constituents in peanuts that affect flavor, aroma, and other important properties of the processed products, as a basis for developing new or improved products and processing procedures. Fundamental studies of peanut proteins and associated materials could similarly lead to the development of new concepts and new uses.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving organic chemists, biochemists, analytical chemists, microbiologists, and chemical engineers engaged in both basic and applied studies on peanuts and peanut products to increase consumer acceptance and extend markets for peanuts.

Research to develop basic information on the chemical composition and properties of peanuts, its constituents, and processed peanut products is carried out at New Orleans, Louisiana. As a part of the Seed Protein Pioneering Research Laboratory's research on various seed proteins, fundamental investigations of peanut proteins and associated materials are conducted to form the basis for developing new concepts and perhaps new uses for peanuts and peanut proteins.

Research on the flavor of peanuts and their processed products is also conducted at New Orleans, Louisiana. One objective is to separate and identify chemical compounds responsible for the characteristic aroma and flavor of freshly roasted peanut products, with special emphasis on the components that change in concentration as the roasted peanuts become stale. The Crops

Research Division of ARS, the Consumer and Marketing Service, and several State Experiment Stations cooperate in the research by providing samples of peanuts of known variety and history. Additional research on flavor is being carried out under contract at the Agricultural Experiment Station, Oklahoma State University, Stillwater, Oklahoma, on a study of the relation of the carbohydrate, amino acid, and protein components of the peanut to the formation of flavor and aroma during roasting.

Certain aspects of microbiology and toxicology as they relate to peanuts and their processed products are being investigated at New Orleans, Louisiana. An important line of such research is the identification, isolation, characterization, and analysis of mycotoxinselaborated by fungi that may develop in these products. Related research is concerned with the development of economically feasible methods for the inactivation or removal of aflatoxins from contaminated peanuts and peanut products to permit their utilization in foods (and feeds). Cooperation is maintained with the Crops Research Division, ARS, Market Quality Research Division, ARS, State Experiment Stations, the Pharmacology Laboratory of WU, the Food and Drug Administration, industry, and nutritionists in USDA, at universities, and elsewhere, in connection with this research. The problem of mycotoxins is also receiving attention in contract research at the Agricultural Experiment Station, Auburn University, Auburn, Alabama, on a study of the limiting environmental conditions for the elaboration of mycotoxins in peanuts; and at the Agricultural Experiment Station, Texas A&M University, College Station, Texas, to develop information relating to processing methods; preprocessing history; distribution of immature, mature, and germinating peanuts; and other conditions such as mold incidence as they affect consumer-use properties of processed peanut products.

Research on technology for the development of new and improved processes and products is being conducted at New Orleans, Louisiana. One project is concerned with the development of new and improved low-fat peanut products and processes for their manufacture. Informal cooperation is maintained with peanut suppliers and processors and with nutritionists and home economists for evaluation of experimental products as required. Other research, supported by the Agency for International Development, involves a study of the preparation of peanut flours and their derived products for human consumption in developing countries. Cooperation is maintained with UNICEF for arranging nutritional evaluations of experimental products in developing countries, and with the Human Nutrition Research Division, ARS, for evaluating certain of the products. Suitable processes and processing conditions for inactivating aflatoxins in peanut products by use of basic nitrogen compounds are also being studied; the necessary biologic evaluation is being done by the Pharmacology Laboratory at WU. Additional research on process and product development is being carried out under contract at the Agricultural Experiment Station, Oklahoma State University, Stillwater, Oklahoma, on a study of sterilizing or inactivating treatments in conjunction with artificial drying and curing of peanuts to develop processing conditions needed for producing mycotoxin-free roasted peanut products of optimum quality.

Other research on chemical composition and physical properties is in progress under a grant of P. L. 480 funds to the following foreign institution: The University of Granada, Granada, Spain, for an investigation of the rate of reaction of protein with carbohydrates in peanuts, to provide information leading to improved peanut products, thereby increasing the utilization of this commodity (project duration - 3 years).

The Federal in-house scientific research effort in this area totals 15.7 scientific man-years. Of this number, 2.6 are devoted to chemical composition and physical properties, 2.4 to flavor, 4.1 to microbiology and toxicology, 6.6 to technology--process and product development. The contract research involves an additional 2.3 scientific man-years, 1.0 on flavor, 0.7 on microbiology and toxicology, and 0.6 on technology--process and product development. P. L. 480 research involves one grant on chemical composition and physical properties.

The only line of work to be terminated during the year was contract research on the development of peanut products for use in preparation and fortification of processed and convenience foods (under Technology--Process and Product Development).

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 8.8 scientific man-years is devoted to this area of research.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Chemical, Physical, and Biological Properties and Structural Factors of the Proteins. The Seed Protein Pioneering Research Laboratory is continuing its investigations of oilseeds, primarily peanuts. Research is currently centered on studies of ultrastructure, subcellular particles, newfound enzymes and proteins, immunochemical classification of proteins, and biochemical techniques.

The use of glutaraldehyde fixation and hexane extraction in addition to osmium and permanganate staining has expanded the amount of information obtained in studies of the ultrastructure of seeds with respect to the spherosomes, the oil-storage organelles of oilseeds. Osmium does not immobilize the membranes, but glutaraldehyde and permanganate do. Spherosomes from the peanut and the castor bean were isolated and examined by both techniques. Membranes stained with osmium only appear to swell, forming perfect spheres. By careful hexane extraction of the oil from fixed tissue, "ghosts" which show very distinct membranes were obtained. Storage of oil in nonhexane extracted spherosomes was confirmed by osmium staining.

Investigations of isolated and intact subcellular particles that contain the storage materials of oilseeds have been expanded to include cottonseed,

hempseed, and castor bean, in addition to those begun on peanuts some time ago. Information has been gathered on globoids of cottonseed and peanut, on the protein bodies (aleurone grains) of hempseed and cottonseed, and on spherosomes of peanut and castor bean.

Earlier work on globoids and protein bodies of cottonseed showed that the bulk of the phosphorous of protein bodies was localized in the globoids. This suggested globoids as possible storage cells of high-energy phosphate needed by the seed upon germination. Globoids of cottonseed contain about 3% protein with a glutamic acid/arginine ratio of 0.7. Peanut globoids are strikingly similar, having 3.7% protein with an acidic/basic ratio (aspartic and glutamic/lysine, histidine, and arginine) of 0.9.

Numerous improvements in techniques for isolation of intact protein bodies from seeds now permit these organelles to be purified readily. Protein bodies of cottonseed are 10% protein with a glutamic/arginine ratio of 1.5:1 (the reverse of that found in globoids). In peanuts, the protein bodies (11.6% N and 0.8% P) show the typical amino acid pattern of seed proteins: glycine/glutamic acid ratio of 0.04/1 and acidic/basic ratio of 2.2/1. Protein bodies from hempseed have been isolated and shown to contain pure edestin, the reserve protein, as crystalloids within these organelles--the first time a pure protein has been isolated from a protein body as a crystalloid. This edestin is composed of repeating polygonal-shaped units with a molecular weight of 300,000 (80 Å in size by electron microscopy).

Spherosomes were utilized in an attempt to correlate a biochemical reaction with in vivo morphological changes. By a combination of biochemical reactions and procedures with cytochemical techniques, spherosomes were isolated intact in the fatty layers after centrifuging homogenates of castor beans and peanuts. Lipase activity of the castor bean was localized with the spherosomes, suggesting this organelle as a possible seed counterpart of the animal lysosomes, which contain acid hydrolases. In contrast, peanut spherosomes were devoid of lipase activity, which was associated with the particulate fraction that sediments during centrifugation of the homogenate.

Evidence for several previously unreported enzymes in oilseeds has been obtained. For some, activity has been localized with known particles within the seed. Allantoicase, an enzyme heretofore found only in soybeans, has now been found in peanuts after controlled germination. This enzyme, which splits allantoic acid into glyoxalic acid and urea, was absent in the peanut until after five days of germination. Also, more sophisticated studies of protein bodies have revealed the presence of several enzymes localized there. Acid hydrolases are known to exist in animal lysosomes but were unreported in plants. During the past year, acid proteinase activity has been found associated with the protein bodies of hempseed, cottonseed, and peanut. This suggests that the occurrence of acid proteinase in quiescent seeds may be a universal feature. Another

acid hydrolase--acid phosphatase--was also found associated with the protein bodies of peanut and cottonseed. This enzyme is considered the principal "marker" enzyme of lysosomes. The identification of these two acid hydrolases associated with protein bodies is the first known isolation of lysosome-like particles from plant material with the so-called "latency" phenomenon.

The protein activator of castor bean lipase appears to be a glycoprotein. Its rather high acidic/basic amino acids ratio is similar to that found in castor bean allergens. By use of antisera for total proteins of the castor bean, the lipase activator and some of the characterized allergens were compared. These showed some similar precipitin bands and migration patterns. Specific antisera to the protein activator and to the total proteins are being prepared to determine if the activator is indeed one of the allergens. This would be the first known instance of a biochemical role of allergens in lipid metabolism.

Distribution and changes in the reserve proteins of the peanut before and after germination have also been studied by immunochemical techniques. Eight major and three minor antigenic constituents were detected in total extracts of dormant seed. Arachin, the reserve protein, is the main antigen. The α-conarachin fraction shows two antigenic components; one is anodic and the other is more cathodic than arachin. One antigenic constituent near arachin was characterized as catalase, and another, near α-conarachin, as amylase.

Proteins of the cotyledon and the axial tissue have also been compared by immunoelectrophoresis. Catalase, α_1- and α_2-conarachin, and the main constituents of arachin, are present in both tissues. Arachin concentration in the cotyledon, however, is four times that in the axial tissue. The most striking change noted was the absence in axial tissue of one constituent of the cotyledon migrating as α-conarachin. All other proteins detected appeared in both tissues.

By the upwards flow technique through a Sephadex column, the peanut globulin, arachin, has been separated into two well-defined fractions. The larger fraction is not homogenous, but modifications now underway may improve this. The smaller fraction is of nucleotide origin with a molecular weight of at least 300,000. In addition, a new procedure for isolation of almost pure arachin by low temperature crystallization has been developed. (SU P1).

Under a P.L. 480 project at the University of Granada in Spain, an investigation is being conducted of the rate of reaction of protein with carbohydrates in peanuts as influenced by moisture, oil content, time, and temperature during processing. Substantial progress has been made in the biological evaluation of the effect of roasting on the nutritive value of peanuts in feeding experiments with laboratory animals. Studies of the effect of roasting peanuts at various moisture levels indicate that

moisture may protect protein quality during roasting. These results suggest that maintaining high humidity during dry roasting of defatted peanuts might afford superior protein quality. Experiments have been suggested to determine whether sucrose, the nonreducing sugar normally present in peanuts, enhances the destructive action of heat on the nutritive value of the protein, such as is observed upon the addition of glucose, a reducing sugar, to peanut protein. Work done thus far with Spanish-type peanuts grown in Spain will be extended on a larger scale to the same type peanuts grown in the U.S. Eventually, the basic research being done under this project should lead to peanut products of enhanced flavor, aroma, and nutritive value. (UR-E25-(40)-19).

B. Flavor

1. Identification of Constituents and Factors Influencing Flavor and Aroma of Processed Products. In the investigation of lipid and lipid-soluble constituents of peanuts and their processed products, three phosphatide fractions and a triglyceride fraction obtained from peanut oil were purified adequately for analysis. The phosphatidyl ethanolamine fraction is strongly colored and usually rapidly develps a rancid odor. Thus this fraction may be of primary significance in the stability of oil and hence in its flavor. However, the development of a rancid odor in this fraction does not appear to be related to its fatty acid content, since analysis of the three phosphatide fractions and the triglyceride fraction showed that there are no marked differences in their fatty acid composition. Techniques developed in this research will be of value in separating the classes of lipids in peanut oil for evaluation of their individual contributions to the development of flavor during roasting and to flavor stability subsequent to processing. (S4 1-109(Rev.)).

The contractor (Agricultural Experiment Station, Oklahoma State University of Agriculture and Applied Science) has completed agronomic and organoleptic evaluation of flavor and aroma in the 1965 crop of shelled and unshelled Argentine variety peanuts cured under four conditions and stored under three conditions. Roasted nuts cured in windrows or at 90° F tasted better than those cured at 105° F or 120° F. Studies of chemical data on extracts of aleurone grains suggest that off-flavor bears a complex relationship to amino acids and to sugars. Agronomic data and data on curing and storing of the 1966 crop showed the same trends as previous crops. Data developed should permit selection of growing and processing conditions to yield products of maximum acceptability. The association of various compounds in the aleurone grains with the development of undesirable flavor and aroma upon roasting should provide an objective method for predicting the value of a given lot of peanuts. These data should also be of value to the plant geneticist in selecting the germ plasm for the breeding of peanuts having optimum roasting qualities. (S4 1-119(C)).

C. Microbiology and Toxicology

1. Investigation of Occurrence, Determination, and Properties of Fungi and Toxic Fungal Metabolites That May Develop in Peanuts and Their Processed Products. Contract research at the Agricultural Experiment Station at Auburn University has recently produced the finding that living peanuts, particularly when freshly dug, develop less aflatoxins than do sterilized nonliving peanuts when both types are inoculated with A. flavus and stored under the same conditions. The intact peanut shell affords considerable protection to invasion by mold and production of aflatoxin. Thus, culling peanuts with broken or damaged shells should decrease the possibility of contamination in peanut products. The limiting relative humidity of 86 ± 1% for aflatoxin production in cured peanuts on long term incubation at 30° C confirms previous results from short term experiments and suggests practical means for prevention of contamination. Other evidence obtained in this contract research indicates that varietal resistance may be involved in susceptibility to the production of aflatoxin. (S4 1-121(C)).

In-house research has demonstrated that when Spanish peanuts were inoculated with A. flavus and then stored for a year at 21° C and 65% relative humidity, there was essentially no change in the amount or relative proportions of the different aflatoxins. A study of the relation of the appearance of raw and roasted peanut kernels to aflatoxin content has been completed. In most cases the roasted half of each kernel that contained aflatoxin was darker than the roasted control, but color is not a good criterion for detecting the presence of aflatoxin. The observed decrease in aflatoxin upon roasting--apparent elimination when initial levels in the raw peanut were low--should offer reassurance to peanut processors and consumers. (S4 1-116).

In recently completed contract research conducted by the Agricultural Experiment Station, Texas A&M University, Spanish-type peanuts were studied with the ultimate objective of developing methods to process high-quality peanuts that are free of mycotoxins. The percentage of sound, mature kernels was lower in 1965 than in 1964, although the 1965 kernels were larger. In general, results from the 1965 crop confirmed findings determined for the 1964 crop: that roasted peanuts and peanut butter of superior flavor were obtained from peanuts grown on irrigated plots and that soil fumigation with pentachloronitrobenzene at planting had no deleterious effect on processed product quality and might actually improve flavor. The desirability of field curing or bag curing at ambient temperatures over oven drying at 120° F was also confirmed. Although none of the freshly harvested 1965 lots contained aflatoxin (over 50 ppb), after curing it was found in three bag-dried and one oven-dried lot. (S4 1-120(C)).

Total aflatoxins in a peanut meal (110 ppb) were reduced to none detectable in small scale pilot-plant extractions using 90% acetone-10% water solvent heated to about 120° F. Reductions up to 87% of the total aflatoxins have been achieved when a peanut meal assaying 256 ppb total aflatoxin was

extracted with 90% aqueous acetone in continuous pilot-plant equipment that simulated commercial extraction conditions and equipment. No apparent processing difficulties have been encountered using this solvent. A peanut processor is interested in carrying out a cooperative test to evaluate the process on a larger scale. Biological tests conducted at WU have confirmed that the 90% acetone-10% water solvent, as well as chemical treatments with sodium hydroxide and ozone, are effective in eliminating aflatoxins from contaminated peanut meal without drastic damage to the protein. Paraformaldehyde and dimethylol urea have also proved effective in reducing aflatoxins in the meal. (S4 1-133).

D. Technology--Process and Product Development

1. Peanut Flours and Derived Products for Human Consumption in Developing Countries. During the reporting period, cottonseed rather than peanut flours have received most of the attention in research supported by the Agency for International Development. However, samples of peanut flours have been shipped to various investigators who are cooperating in the evaluation of products designed for human consumption in developing countries. Plans include the development of practical processes to enable relatively small plants in developing countries to produce high-quality flours from both peanuts and cottonseed. (SU-0-0-3(AID)).

2. New Processed Products, Including Partially Defatted Peanut Products. Bench-scale investigations have been directed toward determining the effects of oil and air roasting variables on properties of partially defatted peanuts. To aid in this evaluation, new methods were developed for measuring true density as well as true expansion of the roasted peanuts. Another facet of the research showed that the loss of solubles in excess water during expansion of pressed peanuts increases with time of expansion. In cooperation with a commercial processor, cage presses were used to make partially defatted peanuts. Moisture content is the most important variable to control for maximum removal of oil, whereas age of the peanuts is apparently not a factor. Industrial interest is high--a number of companies are either commercially distributing partially defatted peanuts, in the process of developing partially defatted peanut products for commercial distribution, or producing and selling pressed peanuts for use in the new products. (S4 1-126).

The development of peanut products for use in processed and convenience foods has continued under contract to the Agricultural Experiment Station at Auburn University. Progress has been made in the preparation of screw-pressed peanut flours; evaluation of these flours in bakery, refrigerated, confectionery, and other products; new products in flake and extruded forms; and storage and shelf-life studies. The flours held up very well at room temperature and at 40° F, whereas meals and grits became rancid at room temperature after two to four months' storage time; oatmeal cookie mix became rancid after four months at room temperature but held up fairly well at 40° F. A peanut flake product appears to be potentially useful as

a high-protein breakfast cereal, and peanut products also may find use in such food items as muffins and snacks. A method was developed for preparing full-fat peanut flour, as well as flours with lesser amounts of oil. (S4 1-118(C)).

3. Methods Developed for Inactivating Aflatoxin or Removing It from Contaminated Peanut Kernels. The development of processing conditions to produce optimum-quality, mycotoxin-free roasted peanuts is the objective of a contract awarded to the Agricultural Experiment Station, Oklahoma State University. A reliable and precise laboratory procedure for screening fungicides for the inhibition of proliferation of A. flavus on peanuts has been developed. This technique shows that several commercially available fungicides (Phalatan, Difolatan, Duter, Captan, and Orthocide) appear effective on freshly harvested peanuts at a concentration of 100 ppm. However, the fungicides cannot be expected to be effective indefinitely. Work is now being conducted at fungicide concentrations of 12.5 ppm, and evaluations are being made on combinations of two or more inhibitors. Observations indicate that there is no close relationship between the rating of mold development and the concentration of aflatoxin. (S4 1-132(C)).

Suitable processes employing basic nitrogen compounds to inactivate aflatoxins are being investigated. Continuous ammoniation of prepressed solvent-extracted peanut meal containing 54 ppb aflatoxin B_1 and 18 ppb B_2, performed by a commercial plant in its Expander-Dryer, did not reduce the content of B_2; the maximum detoxification of B_1 was about 35%. However, treatment of the peanut meal with ammonia in a batch operation reduced both aflatoxins to trace quantities. Cooking peanut meal with 1.25% methylamine also appears to be promising. Biological tests conducted at WU have indicated that both ammonia and methylamine are effective in the detoxification of an aflatoxin-contaminated peanut meal, verifying the results obtained with thin-layer chromatographic assays for aflatoxins in the treated meals. Protein efficiency ratios were lowered by the treatments, but the effect was not drastic, and it appears feasible to utilize the detoxified meals in the usual channels, i.e., in the rations for farm animals. (S4 1-139).

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SAFFLOWER, CASTOR, AND OTHER WESTERN OILSEEDS UTILIZATION - INDUSTRIAL PRODUCTS

Western Utilization Research and Development Division, ARS

Problem. Cash crops for diversification and rotation programs need to be increased, particularly in the cotton-producing areas of the western states. A crop with potential for these programs is safflower, which is emerging as an important source of industrial and edible oil, as well as of seed meal that may find uses in foods and feeds. Basic information is needed on the composition of the oil, and this requires development of adequate analytical methodology. Rapid and accurate analytical methods are also needed to control and improve the processing of oil for industrial applications. Safflower oil is particularly valued because of its non-yellowing qualities when used in surface coatings. Breeding research has yielded varieties of safflower with wide variation in fatty acid contents, pointing to the opportunity of growing specific crops for specific applications.

Castor also can provide the diversification that is needed in western growing areas. Utilization research is pointing the way to improved products such as lubricants and foamed polyurethane plastics. Domestic production of castor is so limited that much of our United States requirement must be imported, and large stocks are held by the government as a strategic reserve. Control of allergenic and toxic components of castor meal would make available a high-protein product for feed and food uses. Better utilization of domestic castor seed oil meal could increase the total value of the domestic crop and be an incentive to increase the acreage and thus reduce our dependence on imports. Safflower, on the other hand, has become a significant item of export with 240,000 tons of safflower seed exported in calendar year 1964. This export was essentially all to hard-currency customers, so the export of safflower and the decreased import of castor would both benefit our unfavorable international trade balance. Competition from Eastern European sunflower seed has developed making the research needs of safflower even more critical. Basic and applied research is needed to provide improved processes for and products from safflower, castor and other western oilseeds.

USDA AND COOPERATIVE PROGRAMS

In the Western Utilization Research and Development Division, both basic and applied research are conducted on castor and safflower seed at the Division headquarters at Albany, California; under contract in Tucson, Arizona, and by P.L. 480 grant funds in India. Studies are conducted on the composition of castor and safflower oils and on new products therefrom. New analytical and preparative techniques are developed.

The Federal program of research in this area totals 4.1 scientist man-years, including contract research. Of this total 2.0 are assigned to investigations

on chemical and physical investigations to improve products; and 2.1 to technology--process and product development. In addition, three grants are sponsored under P.L. 480.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 1.5 scientist man-years is devoted to research on industrial and feed uses of other oilseed crops, including safflower.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical and Physical Investigations to Improve Products

1. New Fatty Acid Derivatives from Castor and Safflower Oil for Industrial Uses. We are conducting research to synthesize nitrogen derivatives and related products from castor oil and evaluate them as industrial chemicals. Large laboratory-scale preparations of methyl 12-ketostereate have been improved by exclusion of air to prevent catalyst deactivation. The oxime of 12-ketosteric acid has been obtained in 86% yield. A sample of 12-ketostearonitrile has been prepared from 12-ketosteramide. Low-cost catalytic methods for reducing these compounds to amines are being explored. We are continuing to develop new gas-liquid and thin-layer chromatographic methods for monitoring these synthetic reactions.

Isolated yields of over 70% 10-hydroxydecanoic acid have been achieved from alkaline cleavage of ricinoleic acid or castor oil. We have found that the best reaction media for the cleavage are 1-octanol, 2-octanol, isoctanol and isodecanol. There was no increase in yield of 10-hydroxydecanoic acid when reducing agents such as sodium sulfite, sodium hypophosphite, stannous chloride and aluminum isopropoxide were added to the system.

B. Technology -- Process and Product Development

1. Commercially Useful Polymers Derived from Oils of Safflower, Castor and Other Western Oilseeds. Contract research is underway at the University of Arizona in Tucson to develop plastics, rubberlike products, or related material by polymerization or copolymerization of monomers derived from vegetable oils and naval stores. Vinyl tetrahydroabietate, vinyl dehydroabietate, and vinyl esters of commercial resins were copolymerized with vinyl chloride, vinyl acetate, butadiene and styreneacrylonitrile. Vinyl tetrahydroabietate and vinyl dehydroabietate gave a copolymer of low-molecular weight. Films from vinyl acetate and vinyl dehydroabietate showed poor mechanical properties. All copolymers with vinyl chloride could be molded at 160° C. into transparent somewhat brittle films. Butadiene co-polymerized with vinyl dehydroabietate yielded largely insoluble polymers. Some terpolymer formulations gave strong rubbery films when epoxidized.

A new polymer of vinyl chloride and methyl 12-acryloxystearate (MAS) has shown excellent adhesive properties toward glass plates. Other 12-

acryloxystearate copolymers were rubbery and flexible. Copolymers of 12-methacryloxy-n-amyl stearate and methyl 14-acryloxyeicosanoate were similar to those of MAS. Epoxidation of the terminal double bond of vinyl undecylenate can be achieved with m-chloroperbenzoic acid.

Methods and formulations for commercially feasible continuous production of castor oil-based rigid foamed plastics have been investigated under contract with the Archer-Daniels-Midland Company, Minneapolis, Minnesota. Based on a statistical study of hand-mixed formulations, several castor oil-based foams were selected for large-scale production. The castor oil-based foams were compared with polyether foams. Castor oil formulations had lower physical strength but were less friable and had greater dimensional stability under humid aging conditions. Also, some flame-retardant foams from castor oil were stronger than those from polyether. Sprayed castor oil foams were comparable to similar polyether foams in physical properties, ease of application, and adhesion, but flame-retardance ratings were lower than expected. Excellent froth formulations were obtained using Freon-12 as part of the blowing agent; and shrinkage problems were eliminated. Spray, poured panel, and cut slab formulations are being evaluated under simulated use conditions.

We have initiated a research project to evaluate the utility of urethane polymers from castor oil derivatives as sealants, elastomers, and other solid or cellular plastics.

We have concluded research on a project devoted chiefly to improving the performance and reducing the cost of fluorocarbon-blown rigid urethane foams based on castor oil. Rigid foams with excellent properties were prepared from polyisocyanates and highly hydroxylated castor oil derivatives. Lower cost foams with good strength and insulating properties were developed using mixtures of unmodified castor oil and low molecular weight polyols. The process for making these foams has been licensed by one foam producer, and other concerns have evaluated the foams.

In addition to the foams discussed above, strong rigid foams, utilizing less of the expensive isocyanate component, were prepared by using blown (air oxidized) castor oil.

It was shown that the undesirable increase of thermal conductivity on aging of cut urethane foams is due to diffusion of air into the foam cells at the cut surfaces. Moreover, uncut castor oil-based foams (representative of actual foamed-in-place use) maintain their low initial thermal conductivity as well as do competitive petrochemical-based foams. No evidence of attack by fungi and other microorganisms was found in castor oil-based rigid foams, after 13 months burial in moist earth.

The future growth of rigid foam production depends to a great extent on acceptance by the building industry. Low-cost, flame-resistant foams are

required for this use. Castor oil-based foams have been made flame-resistant, with no loss in physical properties, by incorporation of 10-15% of various hydroxylated phosphorus or halogen-containing flame retardants.

Flame-resistant foams with improved properties, particularly lower shrinkage, have been prepared from crude polyisocyanates and various halogenated castor oil derivatives such as brominated, chlorinated, hypobrominated and hypochlorinated castor oils. Brominated castor oil, the most useful of these derivatives, deteriorates slowly on storage. Suitable means for stabilizing this compound have been investigated.

Particularly interesting flame-resistant foams were prepared from polyisocyanates and adducts of castor oil with perchlorocyclopentadiene. These foams have excellent physical properties and shrink much less after foaming than do comparable foams from unmodified castor oil. These adducts are considerably more stable during storage than simple halogenated castor oils.

Significant kinetic data were obtained while investigating the best conditions for formation of adducts of perhalocyclopentadienes with unsaturated fatty acid derivatives. From the effects of the location of the double bond in the chain, the configuration of the double bond, the presence of a homoallylic hydroxyl group (ricinoleate esters) and whether a perchloro- or perbromo-diene was used, it was concluded that steric factors have a pronounced effect on the rate of reaction of these heavily substituted dienes.

Supported by P.L. 480 funds, the Regional Research Laboratory in Hyderabad, India is conducting research to develop derivatives of safflower oil that will be useful in the manufacture of industrial products. Sulfation, epoxidation, and autoxidation have been studied as promising routes for the introduction of monohydroxy function into safflower oil. A critical study of reaction conditions indicates 78% sulfuric acid at 0°-25° C. and an oil:acid ratio of 1:5 of 1:10 to be optimum, but products have relatively low hydroxy values. Studies with methyl oleate and methyl linoleate indicate the reaction is selective for oleic acid residues and is therefore of little value for hydroxylating safflower oil. Controlled hydroxylation of safflower oil can be achieved by partial epoxidation followed by ring opening by selective hydrogenation after protecting olefinic double bonds with silver. Most recent studies suggest zinc may work as well as the more expensive silver in protecting the double bonds. Autoxidation of safflower oil by aeration under ultraviolet irradiation and subsequent reduction of the hydroperoxides by several techniques lead to products of about 40% hydroxylation. Attempts to increase hydroxylation by repeated oxidation reduction steps yielded dark-colored, viscous products.

The Shri Ram Institute for Industrial Research in New Delhi, India, also supported by P.L. 480 funds, is conducting research to prepare and characterize triacylated monoglycerides of ricinoleic acid and evaluate them as plasticizers. Castor oil monoglycerides of 95-96% purity have been

obtained by counter current liquid-liquid extraction using aqueous alcohol/hexane. Purification by column chromatography was not promising. Liquid-liquid extraction of pure triricinolein, while possible, does not appear practical. Synthesis of glycerol monoricinolein by direct inter-esterification of methyl ricinoleate with isopropylidene-glycerol led to disappointingly low yields; however, the reaction goes smoothly when the free hydroxyl of methyl ricinoleate is first acetylated.

A third research project supported by P.L. 480 funds is conducted at the Regional Research Laboratory in Hyderabad, India. The objective of this study is to prepare intermediates from castor oil hydroxy unsaturated fatty acids that would be useful in making polymers, protective coatings, adhesives and other products. Methodology has been developed, and more than 20 purified monomers have been prepared, characterized and submitted for evaluation.

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SAFFLOWER, CASTOR, AND OTHER WESTERN OILSEEDS UTILIZATION - FOOD

Western Utilization Research and Development Division, ARS

Problem. Cash crops for diversification and rotation programs need to be increased, particularly in cotton-producing areas of the western states. A crop with potential for these programs is safflower, which is emerging as an important source of edible and industrial oil as well as edible seed meal for both food and feed use. Basic information is needed on the composition of the oil and meal and, to obtain this information, adequate analytical methodology must be developed. Rapid and accurate analytical methods are also needed to control and improve the processing of oil and meal.

The high percentage of linoleic acid (essential fatty acid) in safflower oil is a feature that is leading to its rapidly expanding use as a food oil. And breeding research is producing varieties with other advantages. One new variety is very high in oleic acid, providing an oil of unusual stability against oxidation in food products and in cooking. New thin-hulled varieties give greater yields of oil and seed meal, but flavor and color problems exist in the most promising thin-hulled varieties so far developed. Utilization research is required to remove the odoriferous substances and pigments so that a light-colored bland oil is obtained.

Safflower has become a significant item of export, with 240,000 tons of safflower seed exported in calendar year 1964. This export was essentially all to hard-currency customers, so it benefits our unfavorable international trade balance. Competition from Russian sunflower has developed last year so that research is needed to strengthen the position of safflower by improving the value of its products.

Castor also can provide the diversification that is needed in western growing areas. But we anticipate only limited food use of it, although the oil has been used in Asia for centuries for cooking purposes.

Basic and applied research is needed to provide improved processes for and products from safflower, castor, and other western oilseeds.

USDA AND COOPERATIVE PROGRAMS

In the Western Utilization Research and Development Division, both basic and applied research are conducted on safflower and castor seed at the Division headquarters at Albany, California and under contract at Tucson, Arizona. Basic compositional studies on oilseed meals are concerned with the resolution of their water-soluble proteins and determination of their nutrient properties for food. Studies are conducted on the composition and stabilities of safflower oils. New analytical techniques also are being developed.

The Federal program of research in this area totals 5.4 scientist man-years (including contract research) assigned to research on technology -- process and product development.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 2.4 scientist man-years is devoted to research on food uses of other oilseed crops, including safflower.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Technology -- Process and Product Development

1. Development of Highly Stable Safflower Oils. The University of Arizona in Tucson is conducting contract research to identify antioxidants and antioxidant systems in high-stability safflower oils. No correlation appears between tocopherol content and the induction period for oxidation of safflower oils. The addition of propyl gallate to safflower oil gave greater protection from oxidation than an equivalent amount of added tocopherol. A variety of oil samples were evaluated for relative stability. High-oleic safflower oil has about four times the induction period of the best high-linoleic varieties. Stability is related to low linoleic acid content. A series of unrefined safflower oils showed the same relative order of stabilities at both 37° and 50° C. Mixing more-stable and less-stable oils results in a lowering of total stability. Alkali-refined oils are considerably less stable than non-refined oils. Oil-water emulsion systems show increased rates of autoxidation.
We are conducting research to improve the high-temperature stability of safflower oil by elucidating the oxidation and polymerization reactions involved in its deterioration. Volatile oxidation products from safflower oil, methyl linoleate, and 6,9-octadecadiene have been analyzed. They include hydrocarbons, aldehydes, ketones, formate esters and some heterocyclic compounds. Polymeric products from methyl linoleate include dimers containing no additional oxygen as well as dimers with up to four or five oxygen atoms introduced.

High-oleic safflower oil showed less viscosity increase, less polymer formation and less change in fatty acid constituents than ordinary safflower, soybean, cotton seed or commercial hydrogenated frying oils under the conditions of deep fat frying. It performed as well as other oils and remained liquid at low temperatures. Tests have been initiated to compare organoleptic properties of potato chips fried in high-oleic safflower oil with those of chips prepared in commercial hydrogenated oil and regular safflower oil. Early results indicate odor panel preference for the chips fried in the two safflower oils.

2. Nutritional and Useful Foods from Safflower and Other Western Oilseeds. We are conducting research to identify both the useful and deleterious components of safflower seed and meal, and to assess their effects on

the nutritional quality or palatability in foods. The bitter flavor associated with safflower meal can be extracted with ethanol, isopropanol, or acetone containing 20-30% water to yield a bland protein concentrate. Assays show that the extracted material is not metabolized by rats. The meal after extraction and with lysine supplementation is the equivalent of soy meal in available energy and feed efficiency. Laboratory-scale wet milling and elutriation have been effective in removing undesirable fiber from whole seed or meal and larger scale development of the process is underway. A simple procedure has been developed for estimation of lysine (enzymatic method), and the world collection of safflower seed is being surveyed for a high-lysine variety. Thin-hulled, brown-stripe safflower seed yields more oil than commercial seed, but the oil has undesirable odor and color. The odor comes from the hulls and includes alcohols, aldehydes and low-molecular weight fatty acids. Hull oil has been fractionated according to polarity. Saponification of deodorized fractions yields fatty acids with unpleasant odors. Gas chromatograms differentiate brown-stripe from commercial oil. The brown pigment of brown-stripe hulls is an insoluble melanine. Precursors to these melanines, probably phenolic materials, may be extracted with the oil from the kernel. A colorless precursor has been found in unextracted safflower and sunflower oils which forms a pigment on heating to temperatures above 130° C. Methods have been devised to prevent the extraction of this pigment precursor into the oils. Also, a method has been found by which color precursor may be removed from oils containing it.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Technology--Process and Product Development

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SAFFLOWER, CASTOR, AND OTHER WESTERN OILSEEDS UTILIZATION - FEED

Western Utilization Research and Development Division, ARS

Problem. Cash crops for diversification and rotation programs need to be increased, particularly in cotton-producing areas of the western states. A crop with potential for these programs is safflower, which is emerging as an important source of seed meal having great possibilities for food and feed use, in addition to its importance as a source of edible and industrial oil. Basic information is needed on the composition of meals and oil, and this in turn requires development of adequate analytical methodology. Rapid and accurate analytical methods are also needed to control and improve the processing of meals and oils for feed and other uses. Thin-hulled varieties of safflower, being developed through breeding research, will provide greater yields of seed meal and oil. We are cooperating with industry, state and federal plant breeders to develop analytical methodology needed to guide these studies.

Castor also can provide the diversification needed in western growing areas. Control of allergenic and toxic components of castor meal would make available a high-protein product for feed and food uses. We import much of the castor oil required for industrial use, but better utilization of domestic castor seed oil meal would increase the total value of the domestic crop and be an incentive to increase the acreage and reduce our dependence on imports. Safflower, on the other hand, has become a significant item of export with 240,000 tons of safflower seed exported in calendar year 1964. This export was essentially all to hard-currency customers, so the export of safflower and the decreased import of castor would both benefit our unfavorable international trade balance. The export of safflower has dropped in 1965 because of competition from Russian sunflower seed. A greater research effort is necessary so that safflower can improve its competitive position.

Basic and applied research is needed to provide improved processes for the products from safflower, castor and other western oilseeds.

USDA AND COOPERATIVE PROGRAMS

In the Western Utilization Research and Development Division, research on developing new and improved feeds from safflower, castor, and other western oilseeds is conducted at Albany, California. The Federal program of research in this area is equivalent to about 4.7 scientist man-years per year.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 1.5 scientist man-years is devoted to research on industrial and feed uses of other oilseed crops, including safflower.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Technology--Process and Product Development

1. Practical Methods for Deallergenizing Castor Pomace for Feed Use. We have developed two commercially feasible procedures for the deallergenization of castor pomace. Suitably low allergen levels result when pomace with 8% added lime and three volumes of water is heated 30-60 minutes at 140° C. With steam alone, pomace must be heated two hours at 175° C. to give satisfactory results. Both processes destroy some heat-labile amino acids, but with supplementation, processed pomace serves as an excellent protein source in chick rations. Feeding trials have been started to determine the value of deallergenized meal in ruminant rations.

2. Improved Nutritional Quality of Safflower Seed and Meal for Feed Use. Information obtained on the composition of safflower seed and meal as related to their food potential is also applicable for their feed use. The bitter flavor associated with safflower meal can be extracted with ethanol, isopropanol, or acetone containing 20-30% water to yield a bland protein concentrate. Assays show that the extracted material is not metabolized by rats. The meal after extraction and, with lysine supplementation, is the equivalent of soy meal in available energy and feed efficiency.

Laboratory-scale wet milling and elutriation have been effective in removing undesirable fiber from the whole seed or meal. Larger scale development of the process is underway.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Technology--Process and Product Development

Layton, Laurence L., Panzani, Raphael, and Corse, Joseph W. 1966. Non-diffusible allergenic contaminant isolated from samples of chlorogenic acid causing allergic reactions: pure chlorogenic acid not an allergen. J. Allergy 38(5):268-79.

Layton, L. L. 1966. Human allergic serum transfer tests in marmosets: diminutive monkeys as substitutes for human patients and volunteers in allergen research and testing. Internatl. Arch. Allergy Appl. Immunol. 30(4):360-7.

Layton, L. L. and Greene, F. C. 1966. Method of deallergenizing castor beans by treating with one molar ammonium hydroxide and with at least one part of water per part of castor bean material. U.S. Patent No. 3,294,776.

Panzani, R. and Layton, L. L. 1966. Allergy to emanations of arthropods clinical and biological correlations: preliminary test of interpretation. Folia Allergologica XIII(4):249-68.

Perlman, Frank and Layton, Laurence L. 1967. Stability and behavior of reaginic antibodies: effects of freezing, thawing, and lyophilizing on skin-sensitizing activity of reaginic sera. The Journal of Allergy 39(4):205-13.

III. MARKETING AND ECONOMIC RESEARCH

OILSEEDS AND PEANUTS - MARKET QUALITY
Market Quality Research Division, ARS

Problem. Harvested oilseeds and peanuts are subject to deterioration in quality and loss in value through insect and fungus attack and contamination, development of mycotoxins, normal metabolic changes, and instability of their oil constituents to atmospheric oxygen. To maintain the quality, more precise information is needed on the biology, ecology, and control of the various insects and fungi that attack oilseeds and peanuts; and on the physical and chemical changes and the environmental factors which influence these changes during handling, storage, transportation, and processing. Recent problems with aflatoxin and with insects developing resistance to protective pesticidal treatments suggest the desirability of a complete revaluation of handling and storage methods for farmers stock peanuts. Attention should be given to developing new procedures that would avoid the problems associated with fungi, insects, and pesticide residues. Also, to insure uniform and standardized products in the marketing channels, new and improved methods and techniques for measuring quality factors need to be developed for use in inspection, grading, and standardization operations.

Peanut flavor is subject to deterioration while in the marketplace through improper aeration, drying, handling, and storing. Earlier studies conducted on the effect of artificial drying on peanut flavor and quality were not conclusive. In addition, studies on shelling of farmers stock peanuts have been initiated and there is need to determine the effect of variables in the drying and shelling operations.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving engineers and chemists engaged in basic and applied research on the quality evaluation, quality maintenance, and development of objective methods of quality evaluation of peanuts, soybeans, and other oilseeds. Research on soybeans is conducted at Washington, D. C., and Beltsville, Maryland, and in cooperation with the University of Missouri, Columbia, Missouri, and the University of Arkansas, Fayetteville, Arkansas; research on peanuts is done at Albany, Georgia, College Station, Texas, and Raleigh, North Carolina, in cooperation with the Texas Agricultural Experiment Station and North Carolina State University.

A P.L. 480 grant with the Vallabhbhai Patel Chest Institute, University of Delhi, Delhi, India, provides for a study of physiological and biochemical factors involved in the production of aflatoxin by Aspergillus flavus. The project runs from 1965 to 1968 and involves $81,921.52 equivalent in Indian rupees.

A P.L. 480 grant with the Hebrew University in Israel provides for a study of the biology of the fungus Asperigillus flavus Link and its infectivity to plants and harmfulness to animals. The project runs from 1963 to 1968 and involves $129,250 equivalent in Israeli pounds.

A P.L. 480 grant with the Istituto di Industria Agrarie, University of Florence, Florence, Italy, provides for a study of the effect of long-term bulk storage upon quality of edible vegetable oils. The project ran from 1962 to 1966 and was extended to 1967 and involves $26,345 equivalent in Italian lires.

The following project terminated during this period: Effects of the natural antioxidants of vegetable oils on change of oil quality during long-term storage. (MQ 3-25)

The Federal effort devoted to research in this program totals 6.0 scientific man-years.

The Department also has a continuing program at Tifton and Savannah, Georgia, where basic and applied entomological research is conducted on the problems of insect infestation, damage, contamination, and pesticide residues in peanuts in the marketing channels. There is cooperation with the Georgia Agricultural Experiment Stations, the Agricultural Stabilization and Conservation Service, the Transportation and Facilities Research Division, growers' cooperative associations, and various industry groups.

The Federal effort devoted to research on prevention of insect infestation was 1.7 scientist man-years. Much of the cross commodity research reported in the organization report for the Market Quality Research Division under "Insect Control in Marketing Channels" is also applicable to the problems in stored peanuts.

PROGRAM OF STATE EXPERIMENT STATIONS

The research effort of the State experiment stations in this area totals 6.0 scientist man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Natural Antioxidants in Vegetable Oils. Secondary oxidation products of heat treated (deodorized) samples of crude oils, refined oils, and oil mixtures were determined by analysis of carbonyl and aldehyde values (this involves 400 samples of refined and crude cottonseed, soybean, corn and safflower oils). A reasonable relationship between the two methods was found. Upon completion of tocopherol determinations, the project will be discontinued. (MQ 3-25)

2. Equipment for Grading Farmers Stock and Shelled Peanuts.

(a) Since fat acidity is a good indicator of the degree of deterioration of peanuts in storage, three methods for this determination were investigated: the AOCS method, a colorimetric method and a conductometric method. The colorimetric and conductometric methods checked closely with the official method. The conductometric method was the fastest and simplest to use. Accuracy of both methods was about the same.

(b) Cooperative tests of harvesting and field drying treatments of Spanish, Runner, and Virginia type peanuts with Agricultural Engineering Research Division personnel in Tifton, Georgia showed that mean flavor-rating differences among treatments were small and not statistically significant. Statistically significant results obtained from the belt drying tests of peanuts conformed to no apparent pattern. In the infrared drying tests, highly significant (at the 1% level) flavor degradation was demonstrated for the most severe treatment (4 minute exposures) for Spanish, Runner, and Virginia peanuts, even though initial moisture levels for Spanish and Runner nuts were below 25 percent.

(c) An experimental chopper was developed to comminute large samples of shelled peanuts, blend and screen the material through a 1/8-inch perforated screen and provide a representative subsample 1/20th of the original sample weight. It will perform the above operations on a 10-pound sample in approximately 5 minutes, including cleanup time, compared to over 20 minutes required for presently used equipment.

The experimental chopper gave representative subsamples for aflatoxin analysis from samples consisting of 600 kernels with only one kernel containing aflatoxin as well as representative subsamples from 10-pound samples of shelled peanuts containing low percentages of contaminated kernels. Subsamples for aflatoxin analysis were found to contain within 30 percent of the correct amount of contaminated material 97 percent of the time when the experimental chopper is used compared to only 45 percent of the time when present chopping equipment with dull blades is used. The blades on present equipment become dull after grinding only five 10-pound samples while the blades on the experimental chopper perform satisfactorily after grinding more than a hundred samples. (MQ 3-29(Rev.))

3. Rapid Detection of Molds and/or Fungal Metabolites in Peanuts.

(a) The rapid multi-column chromatographic method for detection of aflatoxin in peanuts was further improved. Some degree of quantification is possible by making up standard tubes for comparing with samples. Sensitivity is about 15-20 ppb.

(b) Peanut kernels with fungal growth tentatively identified to be Aspergillus flavus by visual examination were surface sterilized and cultured for positive identification of the fungus. The fungus was correctly identified by visual examination on 87 percent of 152 kernels. Although not 100 percent accurate, examination for visible growth of A. flavus on damaged kernels and other kernels was shown to be a simple, effective method to detect loads with high levels of aflatoxin contamination.

A study of the relationship between fat acidity and damge in farmers stock peanuts gave the following results: (1) fat acidity and total damage are highly correlated; (2) removal of damaged peanuts from the samples resulted in a significant decrease in fat acidity; (3) peanut type has an effect on fat acidity; and (4) fat acidity is a good index of mold damage, but it is not significantly better than presently used visual inspection methods. (MQ 3-66(Rev.))

4. Objective Measurements of Market Quality in Raw Peanuts. Six carotenoids have been isolated from peanut oil and four (alpha carotene, zeta carotene, zeaxanthin and flavoxanthin) identified in addition to beta carotene and lutein previously reported. Carotenoid concentration rapidly decreases from the fourth to ninth week following pegging and little change occurs from the tenth to twelfth week. Actual carotenoid content increases from the fourth to seventh week and then remains stable through the twelfth week. Oil content increased from 22 percent at the fourth week to 56 percent at the twelfth week.

The volatile components of normal flavored raw peanuts have been investigated using combined gas chromatography and mass spectrometry. Components isolated by use of high vacuum distillation and identified were pentane, hexane, 1-hexene, acetaldehyde, acetone, methanol, benzene, ethanol, pentanal and hexanal. Hexanal is probably the major base component of raw peanut flavor.

Tests last year indicated that precooling peanuts before heated-air drying may reduce the amount of skin slippage.

A new method developed for estimating maturity in peanuts is based on the measurement of the skin thickness. Immature peanuts have a skin thickness over twice that of fully matured nuts. (MQ 3-88)

5. Physiological and Biochemical Factors Involved in the Production of Aflatoxin by Aspergillus flavus. Selected enzymes, studied to determine the relationship between age of culture and their activity, were shown to decrease in activity with age and to have little activity eight days after growth initiation. Total lipid, phospholipid, protein and kojic acid content of the mycelium were found to increase with culture age. (A7-MQ-7)

B. Quality maintenance in handling, drying and storage

1. Methods of Long-Term Storage of Vegetable Oils and Relation to Oil Quality. Two reports covering research on this project are now being published as a Marketing Research Report and a paper in the Journal of the American Oil Chemists Society. (MQ 2-44)

2. Development and Control of Mycotoxins in Peanuts. A survey of the 1966 crop of Spanish peanuts in the Southwest was conducted in cooperation with TAES, OAES, the Southwestern Peanut Growers and Shellers Associations, Federal-State Peanut Inspection offices of Texas and Oklahoma, C&MS, and CR, ARS. The incidence of aflatoxin contamination of Southwestern Spanish peanuts in 1966 was quite low.

Dry, shelled peanuts were stored in a relative humidity of 85 percent at 25°, 30°, and 35° C. Aflatoxins in greater than trace amounts were not found for periods up to 5 weeks. The prevalence of species of Aspergillus flavus group infecting the kernels also did not increase significantly in this environment unless A. flavus inoculum (spores) was added in large amounts at the start of storage. (MQ 2-103)

A three-year survey of aflatoxin contamination in farmers stock peanuts marketed in North Carolina has been completed. No correlation was found between aflatoxin contamination and local weather conditions, time of marketing or location within the State.

Further studies have been made of the effects of atmospheric composition on the growth of A. flavus on high moisture shelled peanuts which were sterilized with propylene oxide, inoculated with spores from a toxin-producing strain of A. flavus, and stored in controlled atmospheres. The atmospheres used in the studies were 65, 75 and 85 percent carbon dioxide.

The results of a study to determine the effect of various windrow conditions on mold growth and production of aflatoxin showed that a rain during windrowing, particularly after the peanuts have dried below 15 percent moisture content, is probably the primary cause of molding and aflatoxin production after digging. The duration of the rain, air temperature, and humidity also play a role in aflatoxin production. If the rain occurs immediately after digging, the chances of aflatoxin contamination are low, but if it rains several days after digging or after the peanuts have undergone some drying, very likely aflatoxin production will take place. (MQ 2-107)

3. Effects of Storage Temperatures on Quality of Vegetable Salad Oils. Cottonseed and soybean salad oils (with no added synthetic antioxidants) were stored in 1-gallon sealed metal containers under 5 levels of heat

treatment for periods of up to 24 months. Flavor panel evaluations and chemical tests were made at 6-month intervals. Preliminary conclusions indicate that both cottonseed and soybean oils did not significantly change in quality at normal temperatures of dry storage (as compared with samples held frozen). As expected, differences have been found in the keeping qualities of the two oils at higher temperatures. (MQ 2-106(C))

4. Vegetable Oil Storage. For crude oils stored at 50° C, oxidability decreased in the order olive, soybean, and peanut. For refined oils, it was peanut, soybean, and olive. After 900 days of storage at 30° C, crude olive and soybean oils had exceeded the 100 peroxide value. However, crude peanut oil after 1089 days had only a peroxide value of 39. (E15-AMS-12)

C. Prevention of insect infestation

1. Biological and Physical Control. Laboratory tests with nitrogen purging of a simulated storage facility showed that oxygen must be reduced to 2% or less to kill insects in a reasonable time. With carbon dioxide purging, highly effective results were obtained with most insects when oxygen was decreased to 13% or less and carbon dioxide increased to 43% or more. For effective results against larvae of the dermestid beetle, Trogoderma glabrum, it was necessary to reduce the oxygen to 7% or less and raise the carbon dioxide to 60% or more with exposures of less than 14 days. (MQ 1-60)

Tests on the use of carbon dioxide in a commercial structure were conducted in a large concrete silo 113 feet high and 30 feet in diameter, with a volume of 78,000 cubic feet, which was filled with farmers stock peanuts. Plastic tubes were placed at different depths and locations in the silo to sample for carbon dioxide and oxygen concentrations. The carbon dioxide was pumped from a tank truck into the top of the silo. A uniform concentration of 35% carbon dioxide and 14% oxygen was obtained and maintained for 7 days. Laboratory studies had shown these concentrations were effective against many stored-peanut insects. The cost of the gas for a 4-day treatment period was estimated to be slightly more than ½ cent per bushel, a cost competitive with fumigation, but a treatment that leaves no residue. Tests were also conducted in a wooden bin of farmers stock peanuts, lined on the floor, sides, and top with a 12-mil plastic film. Gas analyses revealed good distribution and concentration of carbon dioxide soon after application was completed, but the desired concentration could not be maintained in the bin. (MQ 1-60)

When the almond moth was reared at 27° C. and 60% relative humidity, the life cycle from egg to adult averaged 23.2 days on a laboratory culture medium but required 10.3 days longer on shelled Spanish peanuts. The life cycle of the Indian-meal moth was 1.3 days shorter on the culture medium and 2.1 days shorter on Spanish peanuts. (Exploratory)

Observations were made in farmers stock peanut warehouses at 12 random locations on insect infestations and effectiveness of present control recommendations. There were moderate to heavy moth infestations in some warehouses and very few moths in others. The heavy populations were in warehouses where the malathion surface treatments were not applied adequately. The almond moth was the prevalent species and only 2 warehouses had infestations heavy enough to web over surface areas. Insect damage at load-out was reported to be minor. The first few loads where there was heavy surface infestation had 1 or 2% "worm cut" damaged kernels and the remainder usually averaged less than 0.2% insect damage.

Nine strains of almond moths were collected to determine the degree of malathion resistance. Some of the warehouses have used the malathion treatment for 7 storage seasons. The LD_{50} malathion dosages ranged 9 to 13 times higher than for the standard laboratory strain, about a 3-fold increase over the previous storage season. (Unclassified)

The almond moth and red flour beetle continue to be the prevalent insects in peanut shelling plants. Light trap catches were heaviest from May through September with a peak in August, and were lightest in January and February. Dissection of 1,800 female almond moths from trap catches showed that 99.6% had mated. Examination of the fat body showed the majority of the moths were several days old before they were caught in the traps. (Exploratory)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Quality Maintenance in Handling, Drying and Storage

Taber, R. A. and H. W. Schroeder. 1967. Aflatoxin-producing potential of isolates of the Asperigillus flavus-oryzae group from peanuts (Arachis hypogaea). Applied Microbiology 15: 140-144. (MQ 2-103)

Schroeder, H. W. 1966. Effect of corn steep liquor on mycelial growth and aflatoxin production in Aspergillus parasiticus. Applied Microbiology 14: 381-385. (MQ 2-103)

Prevention of Insect Infestation

Anonymous. 1966. Nitrogen kills flour beetles. International Pest Control 8 (6): 4. (Based on article by Press and Harein 1966.) (MQ 1-60)

Jackson, Curtis R., and Arthur F. Press, Jr. 1967. Changes in mycoflora of peanuts stored at two temperatures in air or in high concentrations of nitrogen or carbon dioxide. Oleagineux 22 (3): 165-168. (MQ 1-60)

Laudani, H., and A. F. Press, Jr. 1966. Control of stored-peanut insects by atmospheric gases. Proceedings, Papers, and Addresses, Fourth National Peanut Research Conference, Tifton, Georgia, July 14-15, 1966, pp. 86-87. (MQ 1-60)

USDA, ARS Information. 1966. Gases kill storage insects. Agricultural Research 15 (2): 7. (Based on article by Press and Harein 1966.) (MQ 1-60)

FIELD CROPS - MARKETING FACILITIES, EQUIPMENT AND METHODS
Transportation and Facilities Research Division, ARS

Problem. Differences in varieties of individual field crops and in the environments of producing areas where they are conditioned and stored, together with advancing techniques in cultural and harvesting practices, require new or modified marketing facilities, equipment, and methods. Such changes are essential to the efficient and economical handling, conditioning, and storing of these crops and to maintaining their quality. There is a need for improved designs for facilities based on functional and structural requirements which will expedite the movement of commodities into, within, and out of the facility. There is also a need for handling and conditioning equipment which will minimize labor and other costs and also minimize the extent of physical damage (breakage) to the grain as it is handled into, within, and out of marketing facilities. More knowledge is needed of the relative efficiency of various handling and conditioning methods so that improved or revised methods and equipment can be developed to perform necessary operations.

USDA PROGRAM

The Department has a long-term program involving engineers engaged in both applied and basic research on, as well as application of known principles to, the solution of problems of handling, storing, and conditioning field crops in marketing channels. Research on the handling, drying, aerating, storing and shelling of peanuts is conducted by the Albany, Georgia, field office at laboratory facilities in Dawson, Georgia, and pilot-scale facilities at Dawson, Georgia, and Holland, Virginia, in cooperation with the Agricultural Experiment Stations of respectively Georgia and Virginia, the Market Quality Research Division, and with various industry firms; and is supplemented by a research cooperative agreement with Tuskegee Institute, Tuskegee, Alabama.

The Federal effort devoted to research in this area during the F.Y. 1967 totaled 19.4 scientist man-years, including 3.8 on the handling, drying, aerating, storing, and shelling of peanuts.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Shelling, Handling, Drying, Aerating and Storing Peanuts

1. Shelling. At Albany and Dawson, Ga., tests were conducted to evaluate four different commercial makes of peanut shellers. Operating speeds of the sheller cylinders were varied from 165 to 325 r.p.m. and peanuts were varied between Spanish-, Runner-, and Virginia-types. The results showed all four makes of shellers increased the amount of split peanut kernels as the cylinder speed increased. Increasing the cylinder speed increased the shelling rate of each

type of peanut only at the lower speeds tested. As these increases in the rates of shelling were accompanied by increases in the amount of split kernels, a compromise between minimum damage and maximum shelling rate is necessary. Tests results also showed that sheller grate size affected peanut shelling differently when the make of sheller was changed. In some tests grates with small openings shelled faster and caused fewer split kernels than grates having larger openings, while in other tests the reverse occurred. Results of tests on sheller bar design showed that the various bars tested had little effect either on the peanut shelling rate or amount of split kernels.

Tests on presizing farmers stock peanuts and sizing shelled peanuts were continued with emphasis on determining the physical characteristics of various peanut types. The average pod size of Spanish- and Runner-type peanuts was 26/64 inch and for Virginia-type was 36/64 inch. Examination showed kernels of Spanish- and Runner-type peanuts close to the hull in small pods. These kernels were split most often during shelling. Conversely, the hulls were much larger (7/64 inch) than the kernels in Virginia-type peanuts, resulting in the larger kernels being split during shelling.

New techniques investigated in shelling peanuts included a centrifugal sheller having a stationary center cone with rubber fingers to rub unshelled peanuts against metal grates. Preliminary tests showed less damage to peanuts but a lower capacity than conventional commercial shellers. Also, limited tests showed Virginia-type peanuts could be shelled with only one-stage, but Spanish- and Runner-types required several stages, the same as conventional shellers.

2. Handling. Tests conducted on two sizes of bucket elevators moving farmers stock peanuts showed that at belt speeds below 380 f.p.m., 9 by 5 1/2-inch buckets on a 12-inch spacing handled more peanuts than the volume of the buckets due to mounding of the peanuts. The maximum rate, 19 tons per hour, occurred at a bucket speed of 380 f.p.m. Reducing the bucket spacing from 12 to 6 inches (or doubling the number of buckets) reduced the maximum handling rate of 18 tons of peanuts per hour at a cup speed of about 300 f.p.m. An elevator having 8 1/2-inch spacing of 6- by 4-inch cups handled 6 tons of farmers stock peanuts per hour at the optimum bucket speed of 320 f.p.m. Reducing the spacing to 4 1/4 inches increased the handling rate only by 1 ton per hour. An evaluation of mechanical damage to the peanuts by the bucket elevator tests was made from official grade data. The results showed an increase of about 0.1 percent in loose shelled kernels and splits combined for each pass through the elevator, while bucket speed had no significant effect.

Tests and experiments, conducted at Tuskegee Institute, Ala., under a research cooperative agreement, to determine the angle of repose and coefficient of friction of farmers stock peanuts were completed but the final report had not been received at the end of the report year.

3. Drying. Tests were conducted on Spanish-, Runner-, and Virginia-type peanuts at Dawson, Ga., and on Virginia-type peanuts at Holland, Va., using an experimental belt dryer. Constant heated-air temperatures of 115°, 130°, and 145° F. were used for intervals of 7.5, 15, 30, and 60 minutes. In one series of tests, 160° F. air was employed initially--then the temperature progressively reduced as drying progressed. A total time of 1 hour per drying pass was used. In the 7.5 and 15 minute exposures to heated air, peanuts were alternately exposed to equal intervals of ambient air. The peanuts also were aerated three or more hours between passes using ambient air at a rate of about 1 c.f.m. per cubic foot of peanuts. Shelling the dried Spanish- and Runner-type peanuts caused less than 5 percent splitting regardless of drying treatment with no significant correlation between drying air temperature and milling quality. However, shelling Virginia-type (Florigiant) peanuts caused an average outturn of split peanuts of about 4, 7, 10 and 14 percent for respective drying air temperatures of ambient, 115°, 130° and 145° F. Shelling Virginia-type (56R) peanuts showed 30 percent more splitting when the heated air temperature reached 145° F. Shelling results also showed exposure times of 15 or 30 minutes to heated air caused fewer split peanuts than an exposure time of 60 minutes. Taste-panel results on the Spanish- and Runner-type peanuts indicated only one lot of Runner-type, dried at 145° F. for 60 minutes (a severe drying treatment), was off-flavor. Although aflatoxin was found in some samples of peanuts, its presence could not be related to the drying treatment. Increases in the rate of drying were directly proportional to increases in temperature and exposure to heated air. The longer aeration period caused a 1.3 to 3.7 times higher drying rate of the peanuts than rates obtained in previous years.

Infra-red drying tests were conducted where Spanish-, Runner-, and Virginia-type peanuts were exposed in a moving single layer for 1, 2 and 4 minutes, then aerated for 3 or more hours between expsoures. Results of official grade determinations showed that significant milling damage occurred only in peanuts in some of the 4-minute exposure tests. Quality tests by Market Quality Research Division showed significant off-flavor of the peanuts occurred only in some of the 4-minute exposures. The presence of aflatoxin could not be related to the drying treatment. An examination of the drying rate showed that the infra-red method dried peanuts about 30 times faster than the experimental belt-dryer.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Shelling, Handling, Drying, Aerating, and Storing Peanuts

Hutchison, R. S. 1966. Research Studies in Drying Farmers Stock Peanuts. Proceedings, Fourth National Peanut Research Conference, Tifton, Georgia.

Davidson, J. I. 1966. Some Performance Characteristics of Conventional Peanut Shellers. Proceedings, Fourth Nat. Peanut Conference, Tifton, Ga.

ECONOMICS OF MARKETING
Marketing Economics Division, ERS

Problem. The marketing system is in a constant state of change. The marketing of farm products continues to become more complex and dynamic because of advances in technology, changes in composition and location of the population, and additional demands for meeting food and fiber needs in much of the world. Not only are structural changes taking place within the marketing segment of the economy but large segments of the processing industry are relocating to meet shifts occurring in labor resources, transportation rates and services, and consumer markets.

The marketing system is imperfect. An ideal marketing system would provide the consumer with a product which has quality and product attributes measured by objective methods, accurately described by understandable terminology, and priced to reflect its true value as determined under trading arrangements where competitive forces are free to operate with adequate market information available to all sellers and buyers. The producer would have complete knowledge about the kind of a product consumers want. Also, he would receive a price that reflects the true value of his product. Handlers and processors would be able to communicate with each other and with producers and consumers in understandable terminology describing product attributes and prices that reflect value differences of well-defined gradations of quality. Our marketing system is lacking in a number of these attributes ranging from almost total deficiency in some to almost ideal in others.

Many decisions made throughout the marketing system are based on limited information. In the production of farm products most decisions are made by the producer but in marketing a great number of decisions pertaining to buying and selling, transporting, handling, storing, processing, packaging, and distribution are made by different persons. At each of these decision-making points there is opportunity to influence the margin between the farm price and the consumer price.

Research in marketing must be conducted in the marketplace. Problems cannot be transferred to a laboratory, experimental plot, or other simulated situation. Cooperation must be obtained from individuals or firms to conduct research activities with privately owned merchandise and facilities where items are bought and sold in a situation where the opportunity for profit or risk of loss exists. Only large firms can afford this type of research, consequently, public research has been requested for the many smaller firms. Furthermore, there is the need for comparison and analysis where even large firms do not have access to the plants and records of competitors.

USDA AND COOPERATIVE PROGRAMS

The Department has a continuing long-term program of economic research designed to provide timely and accurate market intelligence to producers, processors and distributors. The program of work involves both basic and applied aspects of marketing economics research. The program covers commodity and functional problems that are regional or national in scope. In addition to the long-term, on-going research work of the dividion frequently short-term, service-type assignments are carried out for the Secretary of Agriculture or other agencies within the Department having specific problems.

The mission of research in marketing economics is to provide a service for collecting, analyzing, and publishing objective information. The information furnished through research is a form of market intelligence which the private enterprise system utilizes in making decisions in the marketing of farm products. The application of this information within the framework of the competitive system contributes toward improved efficiency in the food and fiber industries which, in turn, helps sustain a viable economy and a high standard of living. Likewise, research findings provide a basis for developing guidelines in public policy as well as concepts for needed new legislation.

Market intelligence sought through research is furnished in areas such as: (1) measurement and evaluation of changes in the structure of the market and the impact of changes on producers, processors and distributors; (2) performance of the market in terms of efficiency and equity are continually being assessed; (3) farm-retail price spreads are maintained on a continuing basis for the major commodities and reported specifically to a congressional committee as well as to the general public; (4) studies in interregional competition, pricing, and transportation form a part of the research program; (5) evaluation of public programs as they relate to the farm economy and public welfare are analyzed; (6) means of improving farmers' bargaining power in the marketplace are continually under study; and (7) work in utilization economics as it pertains to new products and processes form a part of the research effort.

Ideally, market researchers would like to be able to analyze the huge and complex modern marketing system, as an entity at one time, but even with all our advanced technology and modern research methods, a simultaneous analysis is not possible. There is need to select components of the system for analysis. Those selected pertain to: (1) individual firms, (2) competition between firms, (3) bargaining power of farmers, (4) consumer aspects, and (5) location and growth. The activity and effort devoted to oilseeds and peanuts under each research approach are as follows:

A. Efficiency of Resource Allocation in Marketing (1.8 SMY)

This area refers to the efficient use of resources within firms, i.e., outputs of marketing services for given inputs. The inward looking or "in-firm" effect of competition is a continuous effort to become more efficient. Research on the efficiency of performing the marketing functions evaluates the impacts of reduced costs and subsequent adjustments on farmers, marketing agencies and consumers. It relates to the adoption of new technology and innovations by marketing firms and its effect on costs of distributing farm products. In some cases, evaluation of alternative methods of performing the marketing functions is made possible through generating input-output coefficients which demonstrate least-cost methods of performing an individual function. Relationships are shown between costs and alternative methods (innovation and technology) or between costs and volume (economies of scale). Research which describes the flow of products through the various marketing channels is designed to provide sufficient background knowledge to evaluate efficiencies in performing the various marketing functions.

B. The Competitive Situation of Marketing Firms (2.3 SMY)

Competition is generally considered as a regulator of the economy. Although there are numerous forms of competition, price is the common denominator for expressing it in the marketplace. Farmers and businessmen responding to prices choose what products and services to offer and then bid for the resources needed. Performance improves as firms try new ideas and use knowledge gained from research and experience. Research in this area is concerned with the organizational characteristics and practices of marketing firms which affect competition among firms and their relative bargaining position as both buyers and sellers. Studies relate to the measurement and evaluation of concentration, mergers and the various dimensions of integration and diversification of firms. These factors assist in evaluating the marketing position or power of the intermediary marketing agencies. Information on profit ratios and descriptive statistics relating to the farm-retail price spreads and the Marketing Bill serve as benchmark indicators of market position and power.

C. Bargaining and Income Position of Farmers in Marketing (0.0 SMY)

Market power is the ability to influence prices or other terms of trade in a way favorable to a business firm or group. It has long been assumed that, because of the purely competitive structure of the production process in agriculture, farmers are at a disadvantage in the marketing process. Consequently, considerable public enabling legislation has been enacted to strengthen the bargaining and income position of farmers. Examples are the establishment of publicly financed market news, crop reporting and estimating, and legislation to enable farmers to band together in their

buying and selling activities. Farmers also engage in self-sponsored programs such as advertising to differentiate their products in the marketplace. Continuing research is designed to evaluate the effectiveness of these programs and to seek alternative ways in which farmers can organize to strengthen their market and income position.

D. The Role of the Consumer in Marketing (1.9 SMY)

The level of demand for a commodity is commonly thought to be determined by consumers' scales of preference, consumers' incomes or purchasing power, prices of other commodities, expectations about future prices, and number of buyers. This raises the question of how well the changing marketing system serves the consumer. The fact that consumers are continually changing creates an ever-present problem in this area. Research in marketing economics concerns itself with the interests of the consumer as well as those of the farmer and marketing agencies. Research in this area is designed to facilitate the communication of consumers' wants and desires back through the marketing system to the production process. Research is designed to evaluate the nature of demands so that resources can be more efficiently allocated in the production process.

E. Location and Growth Economics (0.5 SMY)

The place where certain activities occur and the extent of those activities are influenced by the kinds of products produced and processed, the technology employed, the channels of trade through which the products move, the size and number of firms, and the trading relationship among firms. Changes in the cost of transportation have probably influenced competition in local markets and between regions as much as changes in total number and size of firms in the nation. This area of work is interrelated with the four areas previously discussed. Studies relating to regional and interregional competition rely on considerations of both the supply and demand of farm products along with considerations of the physical efficiency of performing the various marketing functions. These considerations form a basis for evaluations of the relative location and competitive advantage of individual regions or industries. The relative competitive position of producers and marketing firms in each industry is changing constantly. Changes in transportation rates, costs of inputs, available technology and the organization of industries in various areas have continuous impacts upon the position of each area. Constant evaluation of the changing competitive position of major areas and of prospective further changes is needed by potential investors in considering facilities for processing and storing the production in new and developing regions.

Research studies are often conducted in cooperation with other USDA agencies, other Federal Departments, and State Agricultural Experiment Stations. Cooperative work is undertaken with processors and distributors of agricultural products, transportation agencies, and agriculturally-oriented

groups. Financial contributions to the division's research efforts are sometimes made by industry groups which provide a strengthening of the research effort.

The research program and related program activities are conducted from headquarters in Washington, D. C. A limited number of field stations are located throughout the United States, a major part of them being at land-grant institutions. Field station personnel perform a special service by keeping the division alerted and informed on emerging problems in marketing as well as conducting joint research projects with station personnel. Also, economists are located at each of the four USDA Utilization Research and Development Laboratories. The total effort devoted to marketing research during the reporting year amounted to approximately 118 scientist man-years, of which 6.5 were devoted to oilseeds and peanuts.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Efficiency of Resource Allocation in Marketing

Peanuts

A study of the costs of handling and storing farmers' stock peanuts, initiated at the request of ASCS, was completed during fiscal 1967. The results of this study are presented in the publication ERS-352, Costs of Storing and Handling Farmers' Stock Peanuts in Commercial Facilities, 1965-66. Costs were developed for four primary services performed as a part of peanut handling and storage: cleaning and drying, receiving, loading out, and storage. Standardized costs for handling averaged $2.10 per ton for receiving, and $1.26 for load-out. Standardized storage costs per ton-month stored ranged from $0.51 for Virginia-North Carolina shellers to $1.46 for Virginia-North Carolina warehouses. Cleaning and drying costs ranged from $0.17 per ton received for Virginia-North Carolina shellers to $4.06 for Southeast warehouses. The low cleaning and drying cost for Virginia-North Carolina shellers is due to the small percentage of receipts cleaned and dried by this group of plants.

B. Competitive Situation of Marketing Firms

Soybean and Cottonseed Oils

A study of marketing spreads for soybean and cottonseed oils used in salad dressing has been completed. The price spread between the farm value of oils in a pint of salad dressing and the prices consumers pay has widened during the past two decades. Most of the increase in margins resulted from increased costs of marketing services. Striking differences in retail prices were found between advertised and unadvertised brands of salad dressing. These retail prices varied also by type of retail outlet. A similar study of marketing spreads for vegetable shortening and cooking oils has been initiated.

C. Bargaining and Income Position of Farmers in Marketing

No work reported specifically for oilseeds and peanuts.

D. The Role of the Consumer in Marketing

Safflower Oil

A study is underway of the market potential for safflower oil and meal for industrial, feed, and food use. Particular attention is being given to analyses of use patterns and factors associated with the use or lack of use of safflower. The study is designed to estimate the demand for safflower oil and meal in 1970 and to evaluate factors affecting its use. It also will assist the Western Utilization Research and Development Division, ARS, in establishing priorities and in developing plans for their research on safflower.

Product Development and Utilization Research

Results of past research conducted in the areas of utilization, product development, market potentials, and market development suggest certain types of impacts of new technology on the interdependence between raw material suppliers and consumer product markets. Some of the observed or expected impacts of new technology are (1) changes in the utility of a farm commodity as a raw material used in making consumer products (turbo milling of wheat flour and beam houses and new hide trims for cattle hides); (2) substitution of a synthetic for a farm commodity (corfam for leather and cellulose and petrochemical sources fibers for cotton and wool in textiles); (3) changes in market value of farm commodities because of change in utilization (use of low-grade potatoes, citrus and other products for which consumer demand has increased for processed forms); and (4) shifts in location of production, because of advantages or savings stemming from processing or preserving innovations, and developments in transportation.

In the past year, an important accomplishment has been the completion of a long-range research project in the feed area. Purpose of this research was to evaluate the economics of the new feed ingredients developed by utilization researchers. The evaluation was based on an adaptation of a least-cost linear programming matrix which allowed a determination of the quantity of new feed materials that will meet the formula requirements for different animal rations at least cost, and the price range in which these feed materials must fall to make them competitive with other feeds supplying the same nutrients. Initial attention was given to alfalfa meals of differing protein contents. Eventually, consideration will be given to safflower, castorbean meal, and to mill feeds. Of importance to program guidance in this area is the development of this type of matrix for analysis, coupled with the fact that computers are now available at most of the laboratories and staff members will be able to make computer runs for other new feed ingredients to determine their intrinsic values in different animal rations.

An important phase of the utilization research program is the development of new and improved industrial uses of agricultural commodities. Major economic research efforts to provide guidance to the utilization research program on industrial uses was confined in the past reporting year to the use of starch in textile manufacturing, the impact of non-woven manufacturing on textile use, and future prospects for flaxseed.

The study of the future prospects for flaxseed reveals that its competitive strength in production has weakened over the last two decades (since World War II). Its weakening position in production was mainly due to (1) a constant (stagnant) yield level in the main producing areas while the yield of other crops were increasing and (2) a worsening of the price of flaxseed relative to the price of competing crops. Flaxseed's price has shown this weakness during a period when its production was declining, reflecting weaknesses in the market for its end-use products. Nevertheless, the flaxseed crop apparently has complementary and supplementary influences in the cropping systems that enhances its competitive strength. It has unique features not displayed by its main competitors. Consequently, it is a crop with no good substitutes for particular aspects of cropping systems on many farms in the tri-state producing area.

E. Location and Growth Economics

Soybeans

A study in cooperation with Purdue University analyzes the production and distribution of soybeans giving particular attention to how changes in transportation costs may affect the location and costs of processing and distributing soybeans and soybean products.

Peanuts

Work has been started on the development of an interregional analysis of the peanut industry. The State Experiment Stations in Georgia and Texas, under contract with ERS, are well along on collecting and analyzing data concerning peanut grower harvesting and marketing practices and the costs associated with these activities in their respective areas. This information, along with a considerable amount of other data from various sources will provide the basic input data for an interregional model of the industry.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

A. Efficiency of Resource Allocation in Marketing

Paul, Allen B., and Wesson, William T., November 1966. "Short-Run Supply of Services -- The Case of Soybean Processing," Journal of Farm Economics Vol. 48, No. 4., Part 1, pp. 935-951.

Reimund, Donn A., October 1966. Peanut Marketing. ERS-325, 13 pp. (Reprinted from "Agricultural Markets in Change" AER-95)

Wynn, N. A., Jr., and Reimund, Donn A., May 1967. Costs of Storing and Handling Farmers' Stock Peanuts in Commercial Facilities, 1965-66. ERS-352, 30 pp.

B. Competitive Situation of Input and Output Marketing Firms

Hutchinson, T. Q., August 1966. Transporting U. S. Wheat, Corn, and Soybeans in Export Channels. ERS-305, 8 pp.

Smith, Thomas B., October 1966. Marketing Oilseeds and Oilseed Products. ERS-319, 22 pp. (Reprinted from "Agricultural Markets in Change.")

ECONOMIC AND STATISTICAL ANALYSIS
Economic and Statistical Analysis Division, ERS

Problem. Frequent accurate appraisals of the economic prospects for important agricultural commodities are necessary if farmers are to plan and carry out their production and marketing activities in an efficient and profitable way. The typical farmer cannot afford to collect and analyze all the statistical and economic information necessary for making sound production and marketing decisions. Such information is provided through a flow of current outlook information, the development of longer range projections of the economic prospects for the principal agricultural commodities, and analyses of the economic implications of existing and proposed programs affecting major farm commodities.

Producers, processors, distributors, and consumers need information based on accurate quantitative knowledge of the interrelationships among prices, production and consumption of farm products, and other factors. Similarly, Congress and the administrators of farm programs need such economic information to evaluate existing and alternative programs or policies in terms of their probable impact on production, consumption, and prices at both the farm and retail levels. The research program in this area provides the information for strengthening outlook and situation work, and for appraising alternative policies for agricultural products.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-range program of economic and statistical analysis directed in two major areas: (1) commodity situation and outlook analysis, and (2) supply, demand, and price of agricultural commodities.

The program pertaining to situation and outlook includes a continuous appraisal of the current and prospective economic situation of the major crop and livestock items. These appraisals, together with developments of interest to the industry and results of special studies, are published four to six times a year in the various commodity situation reports. Brief resumes are carried in the quarterly Demand and Price Situation and when appropriate in monthly issues of the Farm Index and the Agricultural Outlook Digest. Pertinent information is also presented at the Annual Outlook Conference, at regional and state conferences, and at meetings with industry groups. Statistical handbooks are published periodically for livestock and a number of the field crops. The current Federal effort involves 19.5 SMY's, of which 1.5 are devoted to fats and oils.

The program of basic research into the factors affecting prices, supply, and consumption of principal agricultural commodities is concerned with four broad areas: (1) measurement of consumer response to price, income, and other factors; (2) measurement of producer response to price and other

factors; (3) measurement of the effect of supply and demand factors on prices to farmers and to consumers; and (4) improvement of statistical techniques for measuring economic relationships in agriculture. The USDA program of research in this area involves 9.5 scientist man-years and is located in Washington, D. C., of which 0.5 SMY are devoted to fats and oils.

PROGRAM OF STATE EXPERIMENT STATIONS

For the most part the States depend heavily on the USDA for across-the-board commodity situation and outlook research. However, the State Extension staff members supplement and adapt such research information to meet the commodity situation of their States. Many of the States carry on supply, demand, and price analyses for the products of their State. Much of the research is commodity-oriented, though some projects are of a highly mathematical and theoretical nature aimed at improving price analyses methodology. While not designed as outlook research, much of the research conducted by the experiment stations contributes to improved understanding of price-making forces, which in turn improves market situation analysis and price forecasting.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Commodity Situation and Outlook

Fats and Oils

Soybeans and soybean products again were of major concern because of their increasing importance to both the domestic and world economies. The relatively high price of soybeans last season, along with increased world supplies of competitive commodities, tended to slow down the rate of increase in utilization of U. S. soybeans. The January 1967 Fats and Oils Situation carried an analysis about soybean oil and meal yield factors and trends in oilmeal production and use. The March issue included an article on the importance of fatty acids as a market outlook for fats and oils. Fatty acids and their many derivatives continue to be a promising market for inedible fats and oils. An analysis of glycerine production and use was carried in the June issue. In the future, most of the increase in production is expected to come from synthetic sources. In September, an article was carried on the rapid increase in sunflower seed production, particularly in the Soviet Union. Sunflower seed competes directly with soybeans as a source of oil and meal in world markets.

B. Supply, Demand and Price

No work was reported specifically for oilseeds.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Commodity Situation and Outlook

Fats and Oils

Kromer, George W. Fats and Oils Situation, published 5 times a year, ERS, USDA, Washington, D.C.

Kromer, George W. January 1967. Factors Affecting Soybean Oil and Meal Yields. Fats and Oils Situation, pp. 29-35.

Gazelle, Stanley A. January 1967. Oilseed Meals: Postwar Trends in Production and Use. Fats and Oils Situation, pp. 21-28.

Kromer, George W. April 1967. Fatty Acids: An Expanding Market for Fats and Oils, Fats and Oils Situation, pp. 27-34.

Kromer, George W. June 1967. Glycerine: Demand Strong for Limited Supplies. Fats and Oils Situation, pp. 24-31.

Kromer, George W. September 1967. Sunflowers Gain As An Oilseed Crop in the United States. Fats and Oils Situation, pp. 25-31.

Gazelle, Stanley A. September 1967. Annual and Seasonal Trends in U.S. Lard Production. Fats and Oils Situation, pp. 32-37.

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